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A MODEL FOR EVALUATION OF REFINERY AND SYNFUELS VOC EMISSION DATA

Volume I. Technical Report and Appendix A

R.G. Wetherold, G.E. Harris, F.D. Skinner, L.P. Provost
Radian Corporation
P. O. Box 9948
Austin, Texas 78766

EPA Contract No. 68-02-3926

EPA Project Officer: R. C. Lagemann
Air and Energy Engineering Research Laboratory
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

AIR AND ENERGY ENGINEERING RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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16. ABSTRACT

The report describes the development of a model for estimating emissions of volatile organic compounds (VOCs) from petroleum refineries and synfuel plants. The model, responding to a need to define a consistent and comprehensive approach for estimating VOC emissions from these two sources, isa modular technique in which the entire spectrum of potential VOC emissions sources was defined in a number of process and utility modules. Each module represents a process or auxiliary unit. The user of the model provides emission source counts and other process information, or uses provided default values. Emissions are calculated using emission factors for each source type. Detailed examples of the application of the model to both refineries and synfuel plants are presented. Such estimates, of considerable interest to the EPA, industry, and the public, are needed in the preparation and review of Environmental Impact Statements (EIS) and permits required by the Clean Air Act. Responding to this need, several studies have been made of VOC emissions, particularly from refineries. Methods for estimating VOC emissions and the results of VOC emissions tests have been published in various journals and at various forums.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Coal Gasification	Pollution Control	13B	13H
Organic Compounds		Stationary Sources	07C	
Volatility	Liquefaction	Synfuel Plants	20M	07D
Refineries	Oil Shale	Synthetic Fuels	13I	08G
Mathematical Models		Volatile Organic Compounds (VOCs)	12A	
Estimating			14G	

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ABSTRACT

Estimates of the emissions of volatile organic compounds (VOCs) from petroleum refineries and synfuel plants are of considerable interest to EPA, industry, and the public. Such estimates are needed in the preparation and review of Environmental Impact Statements (EIS) and permits required by the Clean Air Act. In response to this need, several studies have been made of VOC emissions, particularly from refineries. Methods for estimating VOC emissions and the results of VOC emission tests have been published in various journals and at numerous forums. A need has developed to define a consistent and comprehensive approach for estimating VOC emissions from refineries and synfuel plants.

This study has resulted in the development of a model for performing such estimates. A modular technique was developed in which the entire spectrum of potential VOC emission sources was defined in a number of process and utility modules. Each module represents a process or auxiliary unit. The user of the model provides emission source counts and other process information, or uses default values provided. Emissions are calculated by the use of emission factors for each source type. Detailed examples of the application of the model to both refineries and synfuel plants are presented.

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UNIT CONVERSION FACTORS

It is EPA policy to express all figures in metric, or International System of Units (SI). Much of the supporting data for this study were published in English units, however, and ease-of-use for the end user favored remaining in English units. The following conversion table will allow SI units to be calculated for comparison to other EPA reports.

To Convert From	TO	Multiply by
Atmospheres (760 mm Hg)	Pascals (Pa)	$1.01\text{X}10^{5}$
Pounds per square inch (psi)	Pa	6896.6
British thermal units (Btu)	Joules (J)	$1.05\text{X}10^{3}$
Degrees Fahrenheit (°F)	Degrees (°C)	(°-32) (5/9)
Feet (ft)	Meters (M)	0.305
Inches (in)	Meters (M)	0.025
Square feet (ft^{2})	Square meters (M^{2})	$9.29\text{X}10^{-2}$
Cubic feet (ft^{3})	Cubic meter (M^{3})	$2.83\text{X}10^{-2}$
Barrel of oil (Bbl)	Cubic meters (M^{3})	0.159
US Gallon (Gal)	Cubic meter	$3.78\text{X}10^{-3}$
Gallons per minute (GPM)	Cubic meters per second	$6.31\text{X}10^{-5}$
Horsepower (hp)	Watt	746.3
Pounds (lb)	Kilogram (kg)	0.454

SECTION 1

INTRODUCTION

Over the past several years, VOC emissions from petroleum refineries and synfuels have been of some considerable interest to the EPA, industry, and the general public. The preparation and review of Environmental Impact Statements (EIS) and permitting requirements of the Clean Air Act depend upon emission estimates. In response to this need, several studies have been made of VOC emissions, particularly from refineries. Methods for VOC emissions estimates and results of VOC emissions tests have been published in various journals and at numerous forums.

Thus, a need has developed to define a consistent and comprehensive approach for estimating VOC emissions from refineries and synfuels plants. This study was performed to fulfill this objective. The literature was first searched to identify sources of VOC emission data from refineries and synfuels plants. These data were then used to develop a comprehensive model and calculational approach for estimating VOC emissions from refineries and synfuels plants. The emission model developed in this study is described in this report. The calculational approaches are presented, and examples are included to illustrate the application of the emission model.

All the information, work sheets, and procedures for estimating VOC emissions from refineries and synfuels plants are included in this document and the appendices.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

This report presents a mathematical model for estimating VOC emissions from refineries and several types of synfuels plants. All significant VOC emission sources have been included in the emissions model. A modular technique was developed in which the entire spectrum of potential VOC emissions sources was defined in a distinct number of process and utility modules. This model is convenient, flexible, and functional for developing VOC emissions estimates for very diverse petroleum refineries and synfuels plants.

The model developed in this study has several unique and valuable features. The modules lend themselves readily to individual updating, improvement, and expansion. This can be done without disturbing the integrity of the remaining modules. The model is capable of developing emissions estimates from various levels of information. In the extreme, VOC emission estimates for refineries and synfuels plants can be developed when only the plant type and capacity are known. The results of these "maximum default" cases are presented as Table 2-1.

There are several recommendations for further work which could enhance the model developed in this study. The most obvious is computerization of the model. The modular form of this model is ideal for computerization. A computerized version of the model would allow rapid estimation of VOC emissions and optimization of processing and control techniques for minimizing VOC emissions. Different levels of control could be quickly evaluated under different scenarios. Summaries of emissions from particular sources across modules could be prepared with minimal effort.

VOC emissions from fugitive process sources (valves, pumps, flanges, etc.) represent a significant percentage of total VOC emissions.

Control of emissions from these sources is best accomplished through a leak detection and repair program. This VOC emissions model could ultimately incorporate EPA's leak detection (LDAR) model to allow additional evaluation and emission minimization studies to be rapidly performed. The LDAR is currently in computer form.

The accuracy of the VOC emission estimate is not evaluated by the current model. An assessment of accuracy would require information on the accuracy of the emission source data as well as the equipment counts and loading levels. This information is available (in the form of confidence intervals, standard errors, and other types of error bounds) for some of the data used in developing the model. For other sources, new data are currently being developed which should include an accuracy assessment. The level of accuracy in using the model will also depend on the level of information that the user has available (e.g. equipment counts versus unit capacity levels). The current model could be updated to include levels of accuracy for all default values. These values could then be summarized by appropriate error propagation methods to estimate the accuracy of emission estimates generated by the model.

Obviously, it will be desireable to periodically update the modules as additional emission data become availabe. Additional emission data from synfuel facilities should be available during the next five years. As the model is employed, users will undoubtedly find additional needs which have not been addressed by or included in the current model. These needs should be catalogued for future model improvement efforts.

This VOC emissions model has been evaluated in a preliminary fashion by applying the model to some specific facilities and comparing the emissions estimates to results obtained independently (e.g. through permit procedures). More thorough and objective evaluation could be done through a field testing program. Emissions could be estimated using the model and then measured using transect techniques. The results from this effort could be used to refine, calibrate, and validate the model.

TABLE 2-1.

SUMMARY OF "MAXIMUM DEFAULT" EMISSION ESTIMATES*

The Type A (or topping) refinery can be estimated by:

Emissions (lb/day) = 4,024 + (82.3) (Crude Rate in 10^3 BPD)

The average Type A refinery has a crude capacity of 14,000 BPSD.

The Type B (or cracking) refinery can be estimated by:

Emissions (lb/day) = 13,649 + (82.4) (Crude Rate in 10^3 BPD)

The average Type B refinery has a crude capacity of 66,000 BPSD.

The Type C (or petrochemicals) refinery can be estimated by:

Emissions (lb/day) = 25,339 + (83.1) (Crude Rate in 10^3 BPD)

The average Type C refinery has a crude capacity of 150,000 BPSD.

The Type D (or lubes) refinery can be estimated by:

Emissions (lb/day) = 24,455 + (86.0) (Crude Rate in 10^3 BPD)

The average Type D refinery has a crude capacity of 187,000 BPSD.

The Type E (or integrated) refinery emissions can be estimated by:

Emissions (lb/day) = 30,114 + (86.5) (Crude Rate in 10^3 BPD)

The average Type E refinery has a crude capacity of 312,000 BPSD.

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*See Section 7.2 for more details on these estimates.

SECTION 3

REFINERY AND SYNFUEL PLANT EMISSION DATA

A literature search was conducted to obtain all available information on VOC emissions from petroleum refineries and synfuels plants. The types of synfuels plants included in the search were coal gasification (excluding in-situ gasification), coal liquefaction (direct and indirect), and oil shale processing.

Four major sources of emissions were included in the search: process emissions, product storage, baggable fugitive emissions, and nonbaggable fugitive emissions. Both controlled and uncontrolled sources were considered; if the source was controlled, any available information on the degree and type of control and the rationale for control application was included.

Process operating parameters and physical data were included if they pertained to a process stream for which emission data was expected to be available or if they pertained to any existing emission model. Emission data could include measurements of emission rates, measurements of parameters that could correlate with or predict emission rates, or composition data.

Because of Radian's involvement with EPA IERL in VOC emissions activities over the past seven years, it was expected that very little information of significance would be found of which EPA and Radian were not already aware. A search of the DOE ENERGY data base using the DIALOG Information Retrieval Service bore this out. The search included the last five years. Therefore, the bulk of the information was gathered through the Radian library. Particularly in the refinery area, a great deal of the available information on emissions is the result of EPA/Radian testing efforts.

3.1 REFINERY EMISSION AND PROCESS DATA SOURCES

Most of the emission data were obtained from a few major sources which had been identified from past studies. Only those sources which provided emission factors (or data from which accurate emission factors could be calculated) have been included in the summary Table 3-1. Emission factors for non methane VOC were the only type that were considered. Data regarding individual organic compound emissions and concentrations was not considered, since only total non methane VOC emissions were to be calculated by this model.

Data other than emission factors were also needed to develop a model for estimating VOC emissions from refineries. Emission source distributions as well as process and operating parameters were also obtained from some of the sources listed in Table 3-1.

3.2 SYNFUELS PLANT EMISSION AND PROCESS DATA SOURCES

The information available on VOC emissions from synfuels plants is very sparse and quite spotty. Much of the data that was identified in the early stages of this study was not used in the development of the emissions model. It is summarized in Table 3-2, in some cases, to document the sources and perhaps provide other researchers with some summaries of existing data sources.

TABLE 3-1. SUMMARY OF INFORMATION SOURCES FOR PETROLEUM REFINERY MODEL DEVELOPMENT

U.S. EPA. Assessment of Atmospheric Emissions from Petroleum Refining. Volumes 1 and 5. EPA-600/2-70-075 (a,e). Research Triangle Park, N.C. July, 1980.

- Fugitive source emission factors (baggable/nonbaggable)
- Fugitive emission source counts for selected refinery process units
- Summaries of emission factors for combustion and process point sources

Powell, D., et al, "Development of Refinery Plot Plans," prepared by PES for EPA (Report No. EPA-450/3-78-025. June, 1978.

- Fugitive emission source counts/estimates for refinery process and off-site units
- Heat requirements for refinery process units
- Information from which source distributions (heavy/light liquid, etc.) were estimated
- Example refinery configurations

American Petroleum Institute, "Basic Petroleum Data Book - Petroleum Industry Statistics - Volume II, No. 3," published by API, 2101 L Street, NW, Washington, D.C. 20037. September, 1982.

- Data on volumes of products shipped by various means
- Product distributions from refineries

Blacksmith, J. R., et al, "Frequency of Leak Occurrence for Fittings in Synthetic Organic Chemical Plant Process Units," prepared for EPA/IERL (Contract No. 68-02-3171, Task 001, EPA Program Element 1AB604). September 1980.

- Emission factors for valves and pumps in various types of petrochemical plants
- Fugitive emission source counts in selected petrochemical plants

(Continued)

TABLE 3-1. (Continued)

Cantrell, Aileen, "Annual Refining Survey," Oil and Gas Journal. March 22, 1982. Pages 128-151.

- Average capacities of major petroleum refinery process units
- Distribution of process unit types

AP 42; Third Edition Supplements 1-9 Sections 1.3 Fuel Oil Combustion - 1.4 Natural Gas Combustion, 1.1 and 1.2 Coal Combustion, 4.3 Storage of Petroleum Liquids, 9.1 Petroleum Refining, 4.4 Transportation of Petroleum Liquids.

- Nonmethane hydrocarbon emission factors for the listed sources

Boyd, H. B., et al, "Ethane/Propane Cracking Plants Need Flexibility," Oil and Gas Journal. March 7, 1977.

- Product distributions for cracking plant
- Utilities requirements

Laube, A. H., et al, "Source Category Survey Report for Petroleum Refinery Wastewater Systems," prepared for OAQPS, US EPA, RTP. February 4, 1983.

- Estimates of VOC emission factors for units in the wastewater treating units of refineries

EPA, "Development Document for Effluent Limitations Guidelines and Standards for the Petroleum Refining Point Source Category (Proposed)," John Lum (Project Officer), Effluent Guidelines Division, Office of Water and Waste Management, US EPA, Washington, D.C. 20460. December, 1979.

- Wastewater generation factors for petroleum refinery processing units

Hydrocarbon Processing, "1981 Petrochemical Handbook Issue," HP. November, 1981. Hydrocarbon Processing, "1982 Refining Process Handbook," HP. September, 1981.

- Utilities requirements for petrochemical and refinery processing units
- Energy requirements for petrochemical and refinery processing units
- Process configurations

(Continued)

TABLE 3-1. (Continued)

API, "Manual on Disposal of Refinery Wastes - Chapter 7 - Hydrocarbon Emissions," API, Refining Department, Pub. #931. February, 1976.

- Characteristics and amounts of refinery wastes

Brown & Root, "Technical Evaluation of the Best Available Technology Economically Achievable (BAT) Effluent Limitations Guidelines for the Petroleum Refining Point Source Category," API Publication 4327. June, 1980.

- Wastewater generation factors for refineries and refinery process units
- Comprehensive list of refinery processes

Haynes, V. O., "Energy Use in Petroleum Refineries," Oak Ridge National Laboratories, ORNL/TM-5433. September, 1976.

- Energy requirements for refinery process units
- Data on fuel mixes

TABLE 3-2. SUMMARY OF INFORMATION GATHERED ON EMISSIONS FROM SYNTHETIC FUEL PLANTS

Gangwal, S. K., J. G. Cleland, and R. S. Truesdale. Evaluation of Relative Environmental Hazards from a Coal Gasifier. Research Triangle Institute, Research Triangle Park, NC, 1981.

- Concentration ranges of VOC in products

Hittman Associates. Environmental Assessment Source Test and Evaluation Report--Exxon Donor Solvent Coal Liquefaction Pilot Plant. Prepared for Industrial Environmental Research Laboratory, EPA, Research Triangle Park, NC, 1982.

- Process streams and recycled waters - VOC concentrations (detailed) and flow rates

Sarna, K. R. and D. T. O'Leary. Engineering Evaluation of Control Technology for the H-Coal and Exxon Donor Solvent Processes. Dynalelectron Corporation, Bethesda, MD. Prepared for Industrial Environmental Research Laboratory, Research Triangle Park, NC, 1979.

- HC emissions and flow rates for specific modules

Industrial Environmental Research Laboratory. Environmental Assessment: Source Test and Evaluation Report--Koppers-Totzek Process. Research Triangle Park, NC, 1981.

- Hydrocarbon content of gas exiting H_2S absorber and CO_2 adsorber
- Flow rate approximations

Radian Corporation. Environmental Assessment: Source Test and Evaluation Report--Chapman Low-Btu Gasification. Prepared for Office of Research and Development, EPA, Washington, DC, 1978.

- Product gas and vent HC concentrations and flow rates

Gary, J. H., ed. Eleventh Oil Shale Symposium Proceedings. Colorado School of Mines, Golden, CO, 1978.

- Typical HC concentrations in Lo-Btu and Hi-Btu retort off-gas

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(Continued)

TABLE 3-2. (Continued)

Murin, P. J., T. G. Sipes, and G. C. Page. Environmental Assessment Report, Wellman-Galusha Low-Btu Gasification Technology, Final Report. Radian Corporation, 1980.

- Process vents, product gases - flow rate and VOC concentration for several coals
- Detailed process information, including pumps, valves, etc., for several modes of operation

Hittman Associates, Inc. Environmental Assessment Source Test and Evaluation Report--Fort Lewis SRC Coal Liquefaction Pilot Plant. Submitted to Industrial Environmental Research Laboratory, Research Triangle Park, NC, 1981.

- Operating conditions
- Process water and area runoffs - VOC concentrations and flow rates
- Process information, including pumps, valves, etc.
- Listing of emission points
- Detailed stream VOC analyses

Winton, S. L. and M. D. Matson. Lurgi Process Waters - Projected Characteristics and Treatment Alternatives. Radian Corporation, June 1980.

- Comparisons of organic concentrations in Lurgi, Chapman and Synthane liquors and condensates and in liquors and condensates from several Lurgi's

Radian Corporation. Environmental Assessment: Source Test and Evaluation Report, Wellman-Galusha (Fort Snelling) Low-Btu Gasification, Final Report. Submitted to Industrial Environmental Research Laboratory, EPA, Research Triangle Park, NC.

- VOC concentration in product gas and test burner

Dravco Corporation. Handbook of Gasifiers and Treatment Systems, Final Report. NTIS, 1976.

- Operating conditions
- Utility requirements

(Continued)

TABLE 3-2. (Continued)

University of Oklahoma. Energy from the West: Energy Resource Development Systems Report, Volume III: Oil Shale. EPA Contract No. 68-01-1916.

- Total HC emissions/hr from several plant configurations
- Total organic emissions/hr from several kinds of retorts
- Total hydrocarbons emissions/hr from individual units in Tosco
- Some process information
- Retort gas compositions, yield per ton
- Tankage requirements
- Heat loads for Tosco II

Radian Corporation. Environmental Assessment: Source Test and Evaluation Report--Lurgi-Type (Kosovo, Yugoslavia) Medium-Btu Gasification, Final Report. Submitted to Industrial Environmental Research Laboratory, EPA, Research Triangle Park, NC, 1981.

- Detailed process information, including pumps, valves, etc.
- Overall emission estimates
- Process vents - flow rate and VOC concentration

Radian Corporation. Environmental Assessment: Source Test and Evaluation Report--Wellman-Galusha (Glen Gery) Low-Btu Gasification. Industrial Environmental Research Laboratory, EPA, Research Triangle Park, NC, 1979.

- Coal hopper and Pokehole VOC concentrations and flow rates

Jones, Fred, _et al_. Source Test and Evaluation of a Riley Gas Producer Firing North Dakota Lignite. Presented at the Symposium on Environmental Aspects of Fuel Conversion Technology, Denver, CO, 1981.

- Ambient VOC levels at several points in plant

SECTION 4

DEVELOPMENT OF SYNFUEL PLANT AND PETROLEUM REFINERY VOC EMISSION MODEL

The VOC emission model described in this report is designed to be an aid in calculating the VOC emissions from a petroleum refinery or a synfuels plant. This section describes the format, organization, and basis of the model in general terms.

4.1 MODEL FORMAT AND LOGIC

The VOC emission model is presented in a workbook format in the appendices of this report. The model is comprised of three types of forms:

- calculation sheets,
- default sheets, and
- summary sheets.

The basic emission calculations for all emission sources are done on the calculation sheets. If the person using the model has complete descriptive information about the plant in question, then the calculation sheets would provide everything else necessary to estimate the VOC emissions. In most cases, however, the calculation sheets will require some input data that the user does not have, and the default sheets were designed to provide reasonable estimates for such missing data. The summary sheets are used to tabulate the results of the baseline emission calculations and to estimate the potential emissions for various levels of emission control.

The logic flow of the emission model is illustrated in Figure 4-1. The user first characterizes the plant to be modeled by selecting appropriate process and auxiliary modules from a menu. Process modules are the model's representation of process units (such as a Fluid Catalytic Cracker, a Naphtha Hydrotreater, or a Lurgi Gasifier). Auxiliary modules are the representation of non-process operations (such as wastewater treating, cooling towers, product storage, etc.). If the user does not know which modules should be included, there are several typical refineries and synfuels plants that are fully defined, and these generic plants may be used as is or simply as a guide in structuring the modules.

The emission calculations are done on a module-by-module basis using the emission calculation sheets and the default sheets (as necessary). When all the process modules have been calculated, then a similar procedure is followed for the auxiliary modules. The results of all of these calculations are transferred to various baseline emission survey forms.

The user may also specify additional emission control at the summary level for each source type. It would be outside the scope of this study to provide complete default values for all possible VOC control options, but a few typical emission control systems and their range of control efficiencies are specified for each source type.

4.2 SELECTION OF REFINERY MODULES

The selection of modules to represent refinery processes requires some compromise between ease of use and accuracy of the emission estimate. At one extreme, the easiest model to use would be one that required only a single calculation based on the type of facility and its processing capacity, but such a model can make only very rough estimates of the VOC emissions. At the other extreme would be a model which includes a module for every known refinery and synfuel process. If the information was available to calibrate such a model, it would produce a very accurate emission estimate. The modules

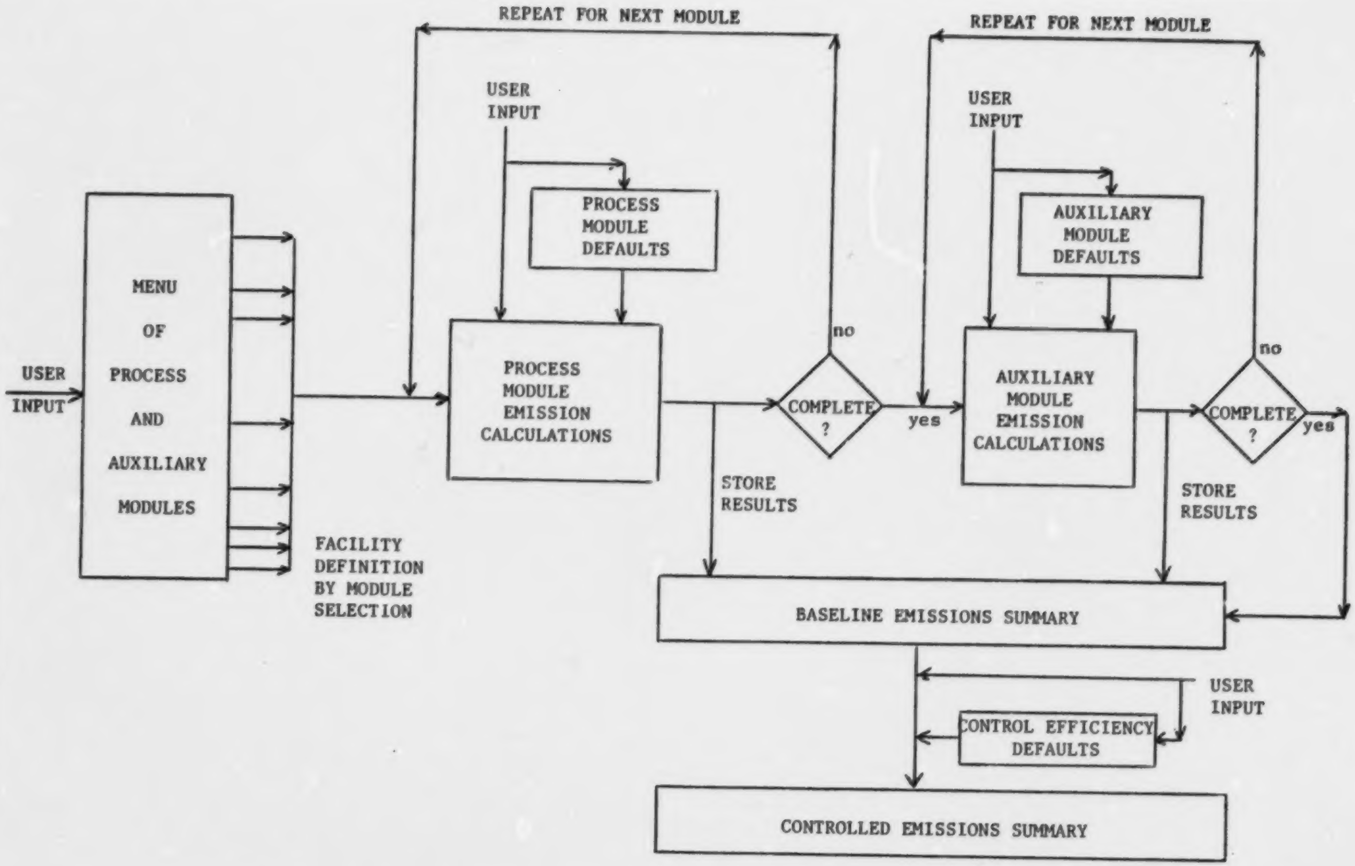
REPEAT FOR NEXT MODULE
REPEAT FOR NEXT MODULE
USER INPUT
MENU OF PROCESS AND AUXILIARY MODULES
FACILITY DEFINITION BY MODULE SELECTION
USER INPUT
PROCESS MODULE DEFAULTS
PROCESS MODULE EMISSION CALCULATIONS
STORE RESULTS
COMPLETE ?
no
yes
USER INPUT
AUXILIARY MODULE DEFAULTS
AUXILIARY MODULE EMISSION CALCULATIONS
STORE RESULTS
COMPLETE ?
no
yes
BASELINE EMISSIONS SUMMARY
USER INPUT
CONTROL EFFICIENCY DEFAULTS
CONTROLLED EMISSIONS SUMMARY

Figure 4-1. Logic Flow Diagram

selected for the VOC emission model represent a compromise between these two extremes based on the following factors:

- modules are defined to represent common refining processes in their generic form (i.e., catalytic reforming, rather than Platforming, Magnaforming, Poweforming, Rheniforming, and Ultraforming),
- modules are assigned only to those processes which potentially make a significant contribution to VOC emissions (while processes like sulfur recovery units are omitted because they have a negligible potential to emit VOC),
- several different processes may be grouped into a single module if they are minor VOC sources (such as the lube oil processes), and
- if no emission or process information is available for a process, it will be added to a module with other processes with similar VOC emission tendencies for which adequate data are available.

In all cases where processes were grouped into a single module, an attempt was made to combine processes with a similar process function.

A variety of references have listed the process units typically involved in petroleum refining (references 1, 2, 3, 4 and 5). The most comprehensive list came from the wastewater flow model prepared for API by Brown and Root (reference 5). This list of processes was used as a starting point. Processes appearing in other references, but missing from the Brown and Root model, were added to the list. After a review of the available emission and process characterization data, this comprehensive list of refinery processes was condensed into the process modules presented in Table 4-1.

TABLE 4-1. LISTING OF REFINERY MODULES

Module Name	Comments
1. Atmospheric Crude Distillation	Includes desalting, heat exchange network, atmospheric column, side stream strippers, etc. Does not include facilities for processing LPG in non-condensible OH gases (see #14).
2. Vacuum Crude Distillation	
3. Naphtha Hydrotreating	For sulfur reduction in straight-run or cracked naphthas.
4. Middle Distillate Hydrotreating	For sulfur reduction in jet fuels and kerosene.
5. Gas Oil Hydrotreating	For low sulfur fuel oils, cracking feed pretreatment, and lube oil hydroprocessing.
6. Vacuum Resid Hydrodesulfurization	
7. Catalytic Reforming	Includes Platforming, Rheniforming, Powerforming, etc. Does not include the naphtha hydrotreating (see #3).
8. Aromatics Extraction	Includes Udex, Sulfolane, Tetra, etc.
9. Catalytic Cracking	Includes fulid and moving bed crackers such as the FCC, HCC, and TCC. Includes reactor, regenerator, main fractionater, and heat exchange. Light ends recovery and fractionation are not included (see #14).
10. Hydrocracking	
11. Thermal Cracking & Visbreaking	
12. Delayed Coking	
13. Fluid Coking	Includes fluid coking and flexicoking

(Continued)

TABLE 4-1. LISTING OF REFINERY MODULES (CONTINUED)

Module Name	Comments
14. Light Ends Recovery and Fractionation	Includes circulating oil absorption/stripping and fractionation of recovered light ends.
15. Other Miscellaneous Fractionation Units	Independent naphtha splitters, rerun stills, stabilizers, etc.
16. Alkylation	Includes both HF and H_2SO_4 alkylation.
17. Polymerization	Production of polymer gasoline from propylene and LPG mixtures.
18. Isomerization	Includes both C_4 and C_5/C_6 isomerization.
19. Lubes Processing - Volatile Organic Solvents	Includes propane deasphalting, propane deresining, propane dewaxing, solvent dewaxing, Duo Sol, solvent deasphalting, MEK dewaxing, MEK-Toluene dewaxing.
20. Other Lube Oil Processing	Includes Phenol extraction, Furfural extraction, acid treating, SO_2 extraction, white oil manufacture, centrifuge and chilling, naphthenic lube oils, clay contacting, wax deoiling, wax sweating, wax neutral separation, and compounding.
21. Asphalt Production	Includes asphalt oxidizing, asphalt emulsifying, Dubbs pitch 200°F softening point unfluxed asphalt.
22. Hydrogen Production	Includes steam reforming and partial oxidation.
23. Gasoline Treating	Includes Merox, inhibitor sweetening, mercapfining, Petreco Locap, Linde, caustic treating, Doctor treating.
24. Other Product Treating	Includes clay treating, Linde, salt treating, and blending for middle distillates and fuel oils.

(Continued)

TABLE 4-1. LISTING OF REFINERY MODULES (CONTINUED)

Module Name	Comments
25. Olefins Production	Production of mixed olefins from gas, naphtha, and/or oil feedstocks.
26. Other Volatile Petrochemicals	Includes butadiene, alpha olefins, aromatics, cumene, cyclohexane, aliphatics, linear paraffins, heptene, MEK, MIBK, Ethyl Amyl Ketone, tertiary amylenes, acetone, isobutylene, hydrodealkylation of aromatics.
27. Other Low Volatility Petrochemicals	Includes naphthalene, xylenes, mineral spirits, Octyl Formal alkylate, styrene, Phthalic anhydride, nonene, Diallylamine, Polyisobutylene chloride, Oxalcohol, Phenol, Cresylic acid, Naphthenic acid, Butyl Alcohols, Pentoxone, Sodium sulfonates, Tertiary butyl toluene, polymers, carbon black, Furfural, catalysts, Mesityl Oxide, Isophorone, gasoline additives, lubricant additives, and oxidates.
28. Boilers	Independent combustion units for production of steam and/or electricity.
29. Blowdown System and Flares	
30. Wastewater Treating	Includes oil-water separators (OWS) and dissolved air flotation (DAF) units.
31. Sludge/Solids Handling	Includes any on-site treatment such as landfarming, landfilling, ponding, etc.
32. Crude and Product Storage	Includes fixed roof and floating roof tanks.
33. Cooling Towers	
34. Product Loading Operations	Includes loading facilities for tank trucks, tank cars, barges, ocean barges, and marine tankers.

4.3 SELECTION OF SYNFUEL PLANT MODULES

Synthetic fuels may be produced by converting carbon-rich solids into combustible gases or liquids which are more easily transported and utilized than the original solid materials. In the United States, the most abundant potential feedstocks are coal and oil shale. Coal-based processes include gasification, indirect liquefaction, and direct liquefaction. Gasification produces gaseous fuels whose heating values vary depending on process and operating conditions.

Indirect liquefaction processes utilize synthesis gas produced by gasification and produce liquid fuels by a variety of catalytic processes. Direct liquefaction produces liquid fuels by combining coal and hydrogen at elevated temperature and pressure.

Oil shale may be processed into liquid fuels by a variety of retorting techniques including in-situ, above-ground, or modified in-situ (a combination of the first two techniques).

Modules were developed for estimating VOC emissions from coal gasification (including gas cooling), three leading indirect liquefaction processes (i.e., Methanol, Mobil M-Gasoline, and Fischer-Tropsch synthesis), direct liquefaction (including initial product separation), and above-ground oil shale retorting.

Additional modules were developed for a number of support processes which may be used in conjunction with synfuels processes. They are as follows:

- Coal preparation. The specific preparation process considered to be a source of VOC emissions is thermal drying, which is required when using some gasification processes.

- Slurry drying. This potentially significant source of VOC emissions is used in some direct liquefaction processes (e.g., Exxon Donor Solvent process) to dry coal prior to liquefaction.

- Acid gas removal. Most synfuels processes produce acid gases (e.g., carbon dioxide, hydrogen sulfide) which must be removed from the raw product gases prior to downstream processing steps due to such factors as product contamination/dilution, or catalyst poisoning. Many acid gas removal processes utilize organic solvents which may produce VOC emissions due to leaks or spills, in addition to VOC which may be present in the gas being treated.

- Wastewater solvent extraction. One of the major categories of organics produced by some synfuels processes is phenolics. In processes where they are present in sufficient concentrations, wastewater pretreatment by solvent extraction may be useful in reducing their loading in subsequent treatment processes. If wastewater solvent extraction is present it may be a significant source of VOC emissions.

Other process steps may be present in synfuels plants including methanation, product gas compression, ammonia recovery, sulfur recovery, and wastewater stripping. However, past experience and engineering judgement indicate that these sources do not represent significant potential sources of VOC emissions.

A module for the removal of oil-soluble arsenic was included in the initial list formulated as a part of this contract. However, no information could be found as to types and numbers of VOC emissions sources present in such processes. It is likely that VOC emissions from this module will be small compared to those from other modules.

Table 4-2 is a list of the synfuels modules which have been included in the VOC Emission Model. Default values have been developed for each of the modules listed and are found in Appendix C.

4.4 VOC EMISSION SOURCES IN REFINERIES AND SYNFUELS PLANTS

There are thousands of potential VOC emission sources in a refinery or synfuels plant, but this variety of sources can be aggregated into the following general categories:

- process fugitive emissions,
- process combustion emissions,
- process point source emissions,
- combustion emissions from boilers,
- blowdown and flare system emissions,
- wastewater treating system emissions,
- sludge/solid waste treating emissions,
- emissions from storage tanks,
- emissions from cooling towers, and
- emissions from product loading operations.

TABLE 4-2. LISTING OF SYNFUELS MODULES

Module Name	Comments
Coal Preparation (Thermal Drying)	
Slurry Drying	Used in EDS process.
Coal Gasification	Includes gas cooling. Fugitive emissions from some gasifiers negligible because they do not provide significant hydrocarbons.
Methanol Synthesis	
Fischer-Tropsch Synthesis	
Mobil M-Gasoline Synthesis	
Direct Liquefaction	Includes product separation.
Above-Ground Oil-Shale Retorting	
Acid Gas Removal	
Oil-Soluble Arsenic Removal	No default values developed due to lack of process information.
Wastewater Solvent Extraction	Example: Phenosolvan process

Most of these sources are common to both refineries and synfuels plants and will be discussed together in Section 4.4.1. Process point source emissions, however, vary with the type of plant and will be discussed separately in Sections 4.4.2 and 4.4.3 for refineries and synfuels, respectively.

4.4.1 Common VOC Emission Sources

Each of the categories of VOC emission sources listed above will be discussed briefly in this section. The emission factors for each source type will be given along with a brief description of the source and the emission mechanism. Some emission control options and their effectiveness are also discussed.

4.4.1.1 Process Fugitive Emissions--

Process fugitive emissions are the result of leakage of VOC from the piping and fittings with which the process unit is constructed. The individual source types and their emission factors are given in Tables 4-3 and 4-4. Note that the emission factors are presented by industry, and that there are some significant differences between industries. The refinery emission factors are supported by the largest data base and are used on the generalized calculation sheets. Modified calculation sheets are also included for petrochemical units and coal gasification units, and these specialized sheets should be substituted for the regular calculation sheet when treating appropriate modules (such as an olefins unit, Lurgi gasifier, etc.).

Pump seals--Fugitive emissions from pumps result from leakage where the drive shaft penetrates the pump body. This leakage is minimized by the application of mechanical seals or packed seals. The emission factors for pump seals are differentiated by the volatility of the liquid being pumped. Light liquids (LL) are defined as any organic material (greater than 10 weight percent VOC) with a volatility higher than kerosene, while heavy liquids are those with a volatility equal to or less than kerosene.

TABLE 4-3. PROCESS FUGITIVE EMISSION FACTORS

Source Type	Service Category	Emission Factors (lb/day/source)	
		Refineries	SOCMI†
Pump Seals	Light Liquid*	6.0	2.6
Pump Seals	Heavy Liquid**	1.1	1.1
Compressor Seals	HC Gas	34.0	12.0
Compressor Seals	Hydrogen***	2.6	-
Valves	HC Gas	1.4	0.30
Valves	Hydrogen	0.43	-
Valves	Light Liquid	0.58	0.38
Valves	Heavy Liquid	0.012	0.012 ††
Connections	All	0.013	0.044
Relief Valves	Gas	8.6	5.5
Relief Valves	Liquid	0.37	0.37 ††
Open End Lines	All	0.12	0.09
Process Drains	All	1.7	-

*Light liquid is defined as any organic material more volatile than kerosene.

**Heavy liquid is defined as any organic material with a volatility equal to or less than kerosene.

***Hydrogen service is defined as a stream with greater than 50 percent (by volume) of hydrogen.

†SOCMI stands for the synthetic organic chemical manufacturing industry. These emission factors may be more appropriate for petrochemical units associated with refineries or synfuels plants.

††These factors were taken from the refinery data since there were not enough heavy liquid sources found in the SOCMI testing to warrant the development of separate emission factors.

REFERENCES:

Refinery - - U.S. EPA, "Assessment of Atmospheric Emissions from Petroleum Refining: Volumes 1 and 5," EPA-600/2-80-075 (a and e), July, 1980.

SOCMI - - U.S. EPA, "Fugitive Emission Sources of Organic Compounds - Additional Information on Emissions, Emission Reductions, and Costs," EPA No. 450/3-82-010, Research Triangle Park, NC, April, 1982.

TABLE 4-4. PROCESS FUGITIVE EMISSIONS FACTORS USED IN THE GASIFICATION, ACID GAS REMOVAL, AND WASTEWATER EXTRACTION MODULES

Source Type	VOC Emission Factor, lb/day/source
Pump Seals - Aqueous	0.0026
Pump Seals - Hydrocarbon Liquid	0.011
Compressor Seals - Hydrocarbon Gas	34.0
Compressor Seals - Hydrogen Gas	2.6
Valves - Hydrocarbon Gas	0.0042
Valves - Hydrogen Gas	0.43
Valves - Hydrocarbon Liquids	0.0057
Valves - Aqueous	0.0026
Connections - Hydrocarbon Gas	0.0005
Connections - Hydrocarbon Liquid	0.0011
Connections - Aqueous	<0.00007
Relief Valves - Gas	0.34
Relief Valves - Liquid	0.0037
Open End Lines	0.12
Process Drains	1.7
Sample System Purging	0.79

*There is some concern over the accuracy of these numbers, since they represent only the gaseous portion of the leak (i.e. they do not include the potential contribution of liquid leaks). There were a number of liquid leaks noted, although most were in aqueous stream service. These factors were included because they are the only source of gasification specific data, but the use of refinery factors may be more accurate if liquid leaks are suspected to be significant.

REFERENCE:

Honerkamp, R.L. and D.A. Dalrymple, Radian Corporation, "Fugitive Emission Testing at the Kosovo Coal Gasification Plant," December, 1982.

Emissions from pump seals can be controlled by either a leak detection and repair program (LDRP) or by specification of equipment with inherently lower tendency to leak (i.e. double mechanical seals). The effectiveness of an LDRP depends on the action level (the screening concentration above which maintenance is required), the rate of occurrence of new leaks and recurrence of previous leaks, the time lag between detection and repair, and the effectiveness of a given repair. The overall effectiveness of such an LDRP on light liquid pumps can vary from about a 47 percent reduction (yearly monitoring, 100,000 ppmv action level, and 15 days lag between detection and repair) to about an 82 percent reduction (monthly monitoring, 1,000 ppmv action level, and 1 day repair lag). A typical value for light liquid pumps would be a 77 percent reduction based on quarterly monitoring, 10,000 ppmv action level, and a 5 day repair lag. For heavy liquid pump seals, the range of control effectiveness for the same programs would be from 0 percent to 71 percent, with a typical value of 31 percent reduction.

Leakage from pump seals can be greatly reduced by specifying different seal technology. Some options include the use of sealless (canned motor) pumps, use of double mechanical seals with a high pressure barrier fluid, and use of double mechanical seals with a low pressure barrier fluid and a degassing vent to a control device. On the average, these seal technologies will reduce pump emissions by 99 percent or more.

Compressor seals--Fugitive emissions from compressors also result from leakage past the shaft seal. Compressor emission factors are divided into hydrogen service (streams containing more than 50 volume percent hydrogen) and hydrocarbon gas service (all gaseous VOC streams with less than 50 percent hydrogen).

Compressor seals can also be controlled by either an LDRP or by advanced seal technology. The range and typical control efficiencies for an LDRP on compressors are:

- 37 percent reduction for yearly monitoring, 100,000 ppmv action level, and 15 day repair lag;
- 90 percent reduction for monthly monitoring, 1,000 ppmv action level, and 1 day repair lag; and
- 80 percent reduction for quarterly monitoring, 10,000 ppmv action level, and 5 day repair lag.

It should be noted that some types of compressor seals cannot be repaired, and that the above reductions apply only to those seals amenable to repair (primarily packed seals on reciprocating compressors).

Compressors can also be fitted with dual mechanical seals, and often use a lubricating oil as the barrier fluid. If the barrier fluid degassing vent is routed to a control device, or if the seal area is so vented, the control efficiency should be 98 percent or better.

Valves--Fugitive emissions from in-line valves (those with closed system piping on both the inlet and outlet sides) result from leakage past the stem seal and the valve packing gland. Valve emission factors are divided into four service categories - hydrocarbon gas, hydrogen, light liquids, and heavy liquids. These service categories are the same as those defined previously under pump and compressor seals.

Although some sealless valve designs are available for use in exotic services, the leak detection and repair program (LDRP) is the only viable alternative for emission control on a plant-wide basis. The emission reductions achievable by a range of LDRP's for valves in each service category are presented in Table 4-5.

TABLE 4-5. CONTROL EFFICIENCIES FOR VALVE LEAK DETECTION AND REPAIR

	Emission Reduction (%)			
	Inspection Frequency	Yearly	Quarterly	Monthly
	Action Level (ppmv)	100,000	10,000	1,000
Service	Repair Lag Time (days)	15	5	1
Gas		70	87	93
Light Liquid		41	74	85
Heavy Liquid		0	0	32
Hydrogen*		70	87	93

*Insufficient data available to establish control efficiencies for hydrogen service - assumed same as hydrocarbon gas service.

Connections--This category of process fittings includes any pipe-to-pipe connector except for welds (such as flanges, threaded fittings, tubing connections, etc.). Fugitive emissions result from leakage past the gasket, threads, O-ring, etc. A single emission factor is used for all services.

Connections tend to leak infrequently and at low levels, so they are seldom included in fugitive emission control programs. An LDRP for flanges would range in effectiveness as follows:

- 0 percent reduction for yearly monitoring, 100,000 ppmv action level, and a 15 day repair lag;
- 54 percent reduction for monthly monitoring, 1,000 ppmv action level, and a 1 day repair lag; and
- 0 percent reduction for a typical program with quarterly monitoring, 10,000 ppmv action level, and 5 day repair lag.

The cost-effectiveness of such an LDRP is poor because of the small reductions and the large population of connections.

Relief valves--This category includes devices used to vent excess pressure from a process vessel to avoid damage during process upset conditions, and they are usually called pressure relief valves or safety relief valves. Rupture disks perform a similar safety relief function, but they are not included in this category. VOC can enter the atmosphere from a relief valve both during an emergency relief and by leakage past the seat on a continuous basis. Only the latter emission mode (continuous leakage) is represented by the emission factor for relief valves, since emergency relief emissions are heavily dependent on the frequency of relief, which is impossible to predict. The emission factors for relief valves are divided into gas service and liquid service. Gas service relief valves are normally mounted on the high point of a vessel and the seat is exposed to hydrocarbon vapor. Liquid service relief valves are normally mounted on the liquid service line near a piece of equipment which might be damaged by a shap pressure surge (such as a shell-and-tube heat exchanger). Liquid service relief valves often discharge directly to a drain.

Relief valve emissions can be controlled by either LDRP or by control equipment. The range of control efficiencies for several LDRP's on gas relief valves is:

- 23 percent for yearly monitoring, 100,000 ppmv action level, and a 15 day repair lag;
- 87 percent for monthly monitoring, 1,000 ppmv action level, and a 1 day repair lag; and
- 65 percent for quarterly monitoring, 10,000 ppmv action level, and a 5 day repair lag.

No data are available concerning LDRP effectiveness for liquid service relief valves.

Relief valve emissions can also be controlled by equipment modification. One method is to route the relief valve discharge into a closed collection system leading to a flare, which should reduce emissions by about 98 percent. It is also possible to mount a rupture disc upstream of the relief valve, which effectively eliminates any continuous leakage through the relief valve.

Open end lines--The valves discussed previously were in-line valves (i.e., those with closed piping connected to both inlet and outlet sides), but it is also common to find valves with the outlet side open to the atmosphere. Emissions from these open ends occur because of leakage past the valve seat rather than through the stem seal. Open end lines are used as drains, sampling sites, high point degassing vents, etc. The emission factor for open end lines covers all services.

Emission control for open end lines is accomplished by installing a cap or plug when the line is not actually in use. These methods are 99%+ effective in reducing emissions.

Process drains--When water contaminated with organics is routed to a process drain, VOC emissions can occur because of evaporation of the organics. A process drain is usually provided for each pump and most process vessels. The emission factor for process drains is given for all services combined.

Control of VOC emissions can best be accomplished by minimizing the input of organic materials. It is also common to provide an inverted U-tube trap to prevent vapors from flowing up out of the drain from the sewer main. This type of trap does not prevent the evaporative emissions of organics routed to that particular drain, since the organic material tends to form a layer on top of the water in the trap and is exposed to considerable weathering. It is possible to construct a closed drain system with vents to the flare, but this level of control has only been attempted in units processing highly toxic materials, not for basic VOC control. For most cases, it should be assumed that fugitive emissions are not economically controllable.

Sample system purging--Each time a sample of process fluid is taken for analysis, it is common practice to flush out the line so that the sample is representative of current operations. The material flushed out may be collected in open buckets or simply spill on the ground, with considerable evaporative emissions resulting in either case. The emission factor for sample system purging covers all services.

The control of sample purging emissions is accomplished by a closed-purge sampling system, which is designed so that the purged VOC is returned directly to the system or sent to a closed collection/disposal system. These systems are essentially 100 percent effective in reducing sample purging emissions.

4.4.1.2 Combustion Emissions From Heaters and Boilers--

Many refinery processes require a great deal of heat input, which is often provided by the fired process heater. Other processes use steam to provide process heat which was generated in a boiler. VOC emissions from heaters and boilers result from incomplete combustion of the fuel and/or from reactions between the products of incomplete combustion. Most refinery process heaters burn a fuel gas which typically results in very low VOC emissions. VOC emissions from combustion of fuel oil and coal are higher than for gas, but still small compared to other refinery VOC sources. The primary method of controlling VOC emissions from heaters and boilers is maintenance of proper combustion conditions (primarily sufficient excess air), and this is assumed to be the baseline case. No further control is economically practical. Emission factors for combustion sources are given in Table 4-6.

4.4.1.3 Blowdown and Flare Systems--

Flares are used in the petroleum refining industry as a means of handling large emergency releases from process units and for combusting continuous, low flows of VOC that are transported by closed vent systems. The VOC emission reduction efficiency of flares used in refineries is uncertain because measurement methodologies have not been completely developed. Flare destruction efficiencies may range from 91 to 100 percent for perfectly maintained, modern flares burning easily combusted gases. A mean destruction efficiency of 99 percent is normally assumed. Emission factors for the blowndown and flare system for a complete refinery are given in Table 4-7.

The best available flare design is the smokeless flare. A smokeless flare is desirable because any smoke produced during flaring of VOC contains particulate, carbon monoxide, and unburned or partially oxidized VOC. The smokeless flare minimizes the amount of VOC emitted by injecting steam or air into the VOC stream that is present in the flare header. The injection of steam or air increases the mixing of gases within the flare zone thereby increasing destruction of the VOC. This type of flare is considered as the baseline practice for the VOC model.

There are a number of engineering practices currently in use which help flares achieve improved operation. One system involves the use of staged elevated flare systems, where a small diameter flare is operated in tandem with a large diameter flare. The staged elevated flare system is designed such that the small flare takes the continuous low flow releases (such as seal oil degassing vents) and the larger flare accepts large intermittent

TABLE 4-6. EMISSION FACTORS FOR HEATERS AND BOILERS

Fuel Type	Emission Factors ($lb/10^6$ Btu) Industrial Heaters and Boilers ($< 100 \times 10^6$ Btu/hr)	 Utility Boilers ($\geq 100 \times 10^6$ Btu/hr.)
Natural Gas	0.0029	0.001
Fuel Oil	0.0667	0.0667
Coal (Bituminous or Lignite)	1.0 lb/ton	0.3 lb/ton
Coal (Anthracite)	negligible	negligible

REFERENCE: U.S. EPA, "Compilation of Air Pollution Emission Factors - Third Edition, Supplements 1-9," Publication AP-42.

TABLE 4-7. EMISSION FACTORS FOR WASTEWATER TREATING BLOWDOWN SYSTEMS/FLARES AND COOLING TOWERS

Source Type	Emission Control	Emission Factor
Wastewater Treating		
Oil/Water Separator	Uncovered	1.88 lb/10^3 Gal. WW
Oil/Water Separator	Covered	0.38 lb/10^3 Gal. WW
Oil/Water Separator	Covered and vented to flare	0.06 lb/10^3 Gal. WW
Dissolved Air Flotation	NA	0.09 lb/10^3 Gal. WW
Blowdown and Flares	NA	0.8 lb/10^3 Bbl. Crude
Cooling Towers	NA	6 lb/10^6 Gal. CW

REFERENCES:

Wastewater - Laube, A.H. and J.C. Dickerman, "Source Category Survey Report for Petroleum Refinery Wastewater Systems," prepared by Radian Corporation for U.S. EPA/OAQPS-RTP, February 1983.

Blowdown, Flares, and Cooling Towers -

U.S. EPA, "Compilation of Air Pollution Emission Factors - Third Edition, Supplements 1-9,"Publication AP-42.

flows (such as relief valve discharges). A second system involves the use of a small, separate line to the flare tip for continuous low volume, low pressure releases. The small conveyance line is used in order to maintain higher exit velocities of gases entering the flare head, thereby aiding combustion of the low flow VOC stream. A third system, sometimes used in conjunction with either of the above systems involves the use of flare gas recovery. In the third system, a compressor is used to recover the continuously generated flare gas "base load." The compressor is sized to handle the "base load," and any excess gas is flared. No quantitative data are available on the emission reductions for these advanced systems.

4.4.1.4 Wastewater Treating System Emissions--

The primary sources of VOC emissions from wastewater treating systems are evaporative emissions from oil-water separators (OWS) and dissolved air flotation (DAF) units. Other wastewater treating steps may have some small amounts of VOC emissions, but they are negligible when compared to the OWS and DAF. The most common emission control technology for OWS and DAF is the use of covers. Further control can be achieved by covering and venting the off-gases to a flare. The baseline for current practices is to cover the OWS (but not vent to the flare) and to leave the DAF open. The emission factors for each of the control technologies are given in Table 4-7.

4.4.1.5 Sludge/Solid Waste Treating--

Many refinery oily wastes contain some volatile compounds, and atmospheric VOC emissions can result from land disposal of these wastes. The most important disposal methods are landfarming, landfilling, and surface impoundment (or ponding). There are no well established emission factors for any of these operations, but several predictive models have been proposed to estimate emissions, and these models are presented in Appendix B. Some potential control technologies include:

- subsurface injection for landfarming,
- impermeable caps and gas wells vented to a flare for landfilling,
- floating covers for ponds,
- pretreatment before disposal (steam stripping), and
- alternate disposal technique (incineration).

There are no quantitative estimates of the emission reductions for these controls.

4.4.1.6 Storeage Tanks--

Tremendous volumes of crude and petroleum products must be stored at a refinery to allow smooth operation. Depending on the volatility of the material stored, the following types of tanks may be used:

- fixed roof tanks,
- external floating roof tanks,
- internal floating roof tanks,
- fixed roof tanks with vapor recovery, and
- pressurized tanks.

The baseline practice for this model is assumed to be compliance with the NSPS for storage of petroleum liquids for new tanks, or the EPA Control Techniques Guidelines for existing tanks.

There are no emission factors for tanks, but there are some excellent (if complex) models to predict emissions. These predictive models and default values for the inputs for fixed roof tanks and for floating roof tanks are given in Appendix B.

Additional emission control for tanks can be achieved by adding a floating internal cover to a fixed roof tank or by adding a vapor recovery system. Similarly, a floating roof tank could add secondary seals, a fixed cover, or a fixed cover and a vapor recovery system. A tank with vapor recovery could be replaced by a pressure vessel. The emission reductions for these modifications can be estimated by calculating the emissions before and after. A tank with an internal floating cover is calculated like a floating roof tank, but using a minimum wind speed of 4 miles per hour. The emissions of tanks with vapor recovery are dependent on the efficiency of the recovery/destruction device, which might range from 50 percent for a simple condensation system to greater than 98 percent for a combustion system. Pressurized tanks are assumed to have zero emissions.

4.4.1.7 Cooling Towers--

VOC emissions from cooling towers result when a leak occurs in one of the shell-and-tube heat exchangers through which the cooling water circulates. These leaks are infrequent and are repaired rapidly when detected. As a result, the emissions level from cooling towers is quite low. No further methods of control are known at this time. The emission factor for cooling towers is given in Table 4-7. It has been noted that some new synfuels facilities have proposed using partially treated wastewater as cooling tower make-up. No emission factors were found for such an operation, so it should be recognized that the model will under-predict for such cases.

4.4.1.8 Product Loading Operations--

VOC emissions result from evaporation of products being loaded into a variety of transport devices. The emission factors, presented in Table4-8, are divided by stock, by means of transport, and by the style of loading (splash, submerged fill, bottom fill, vapor balance, etc.). The factors are given for the five most common stocks transported - gasoline, jet naphtha, kerosene/Avjet, No. 2 fuel oil, and No. 6 fuel oil. The emissions for loading of other stocks may be estimated by selecting one of the five which is closest in volatility to the stock of interest, or API Publication 2514-A (Sept., 1981) presents a continuous estimation method.

TABLE 4-8. EMISSION FACTORS FOR PRODUCT LOADING

Vehicle	Loading Style	Emission Factor ($lb/10^3$ Gal.) Gasoline	Jet Naphtha	Kerosene	No. 2 Fuel Oil	No. 6 Fuel Oil
Tank Trucks/ Tank Cars	Submerged-normal	5.0	1.5	0.02	0.01	0.0001
	Splash-normal	12.0	4.0	0.04	0.03	0.0003
	Submerged-balanced	8.0	2.5	NA	NA	NA
	Splash-balanced	8.0	2.5	NA	NA	NA
Barges	Clean-vapor free	1.2	1.2	0.13	0.012	0.00009
	Uncleaned-dedicated	4.0				
	Average condition	4.0				
Ocean Barges	Clean-vapor free	1.3				
	Uncleaned-dedicated	3.3				
	Ballasted	2.1				
Marine Tankers	Clean-vapor free	1.0	0.5	0.005	0.005	0.00004
	Ballasted	1.6				
	Uncleaned-dedicated	2.4				
	Average condition	1.4				

REFERENCE:

U.S. EPA, "Compilation of Air Pollution Emission Factors - Third Edition, Supplements 1-9, "Publication AP-42.

There are emission factors given for several different loading styles, and these can be used to estimate emission control potential for improving the operation. Alternatively, a vapor recovery system could be added, the efficiency of which would depend on the ultimate disposal of the vapors.

4.4.2 Process Point Sources in Refineries

The major process-related point sources of VOC in refineries are catalytic cracking regenerators, fluid coking burners, vacuum system vents, and air blowing (primarily of asphalt). Each of these sources and the applicable emission control technology will be discussed briefly. The emission factors for these sources are presented in Table 4-9.

4.4.2.1 Catalyst Regeneration--

Catalysts are used in many refinery operations, and most of these must be periodically regenerated by burning off coke deposits. For most fixed bed catalysts, such as reforming, hydrotreating, and hydrocracking, regeneration is only required at infrequent intervals (several times per year, at most). These intermittent sources are a negligible source of VOC.

The catalytic cracking processes (FCC, TCC, and HCC), however, have a much higher coke laydown rate and must be regenerated on a regular basis. The calculation sheet for this module has an emission factor for an uncontrolled catalytic cracking regenerator, but the baseline for current practice calls for control by either a CO boiler or by using oxidation-promoted regeneration technology. The FCC regenerator is a negligible source of VOC when using either of these emission controls.

4.4.2.2 Fluid Coking--

The fluid coking process is very similar to the FCC, except that coke particles replace the catalyst and the net coke made is a product. The coke burner/heater performs much the same function as the FCC regnerator, and it can be controlled by the same method - the CO boiler. The module default sheet gives an emission factor for an uncontrolled fluid coker, and the emissions should be negligible when using a CO boiler.

TABLE 4-9. EMISSION FACTORS FOR REFINERY POINT SOURCES

Process Unit	Point Source	Emission Control	Emission Factor
Catalytic Cracking	Regenerator Flue Gas	None	220 lb/10^3 Bbl. Fresh Feed
Catalytic Cracking	Regenerator Flue Gas	CO Boiler or complete regeneration	Negligible
Fluid Coking	Burner Vessel Flue Gas	None	135 lb/10^3 Bbl. Feed
Fluid Coking	Burner Vessel Flue Gas	CO Boiler and/or Scrubber	Negligible
Vacuum Distillation	Vacuum System Vent	Barometric Condensers	18 lb/10^3 Bbl. Feed
Vacuum Distillation	Vacuum System Vent	Surface Condensers or Mechanical Pumps	Negligible
Asphalt	Air Blowing Stack	None	60 lb/ton asphalt
Asphalt	Air Blowing Stack	Incineration	1.2 lb/ton asphalt

REFERENCE:

U.S. EPA, "Compilation of Air Pollutant Emission Factors - Third Edition, Supplements 1-9," Publication AP-42.

4.4.2.3 Vacuum System Vents--

A typical vacuum producing system uses steam ejectors plus some way to condense the steam. This condensation may be done by a barometric condenser or a surface condenser. There is a small non-condensible stream that must be vented in either case, and that vent is a potential source of VOC emissions. The most common control scheme is to route the vented gases to the flare system for 98%+ destruction. The use of surface condensers also minimizes the subsequent evaporative emissions from the condensed material. Another alternative is the use of a mechanical vacuum pump with a non-condensible vent routed to the flare. Use of either surface condensers or a vacuum pump along with flaring the non-condensible gases will result in negligible VOC emissions.

4.4.2.4 Air Blowing--

Air blowing is used to increase the melting temperature of asphalt. Although the asphalt is very low in volatility, the exit air does pick up some VOC. These emissions may be controlled by either scrubbing, incineration, or both. The controlled emissions from air blowing are negligible.

4.4.3 Process Point Sources in Synfuels Plants

The point sources of VOC emissions which may be present in a baseline synfuels plant are described briefly in this section, together with uncontrolled emission factors and potential control measures.

4.4.3.1 Coal Drying Vent Gas--

Thermal drying may result in partial devolatilization of the feed coal. The devolatilization products will contain varying amounts of volatile organics, depending on the dryer operating temperature and the chemical properties of the coal. The only data found on the VOC emissions from coal drying were for a batch-wise autoclave dryer used to dry coal at the Kosovo gasification complex (reference 6). An emission factor of 8.4×10^{-3} lb VOC per ton of coal dried was calculated based on data from this reference.

Emissions from the coal drying vent may potentially be controlled by routing the gas to an incinerator or boiler. However, since the concentration of combustibles in the dryer vent gas is likely to be low, this may not be cost-effective.

4.4.3.2 Slurry Drying Vent Gas--

This VOC point source may be present in some direct liquefaction processes, specifically the Exxon Donor Solvent (EDS) process. The available source (reference 7) indicates that the VOC concentration of this vent gas may be significant - roughly 4 percent in a stream consisting mainly of nitrogen. Data from the reference result in a baseline emission factor of 3.8 lb VOC per ton of coal feed. Incineration will probably be used to control VOC emissions from this source; it is assumed to be used in the EDS design report (reference 7).

4.4.3.3 Coal Gasification Low-Pressure Lock Hopper Vent Gas--

For those gasifiers which feed coal through pressurized lock hoppers into the reactor vessel, a potential VOC point source is the gas vented during the lock hopper depressurization cycle. The source is more significant when process gas is used as the pressurant as opposed to gases such as nitrogen or carbon dioxide. The vent gas released as the lock hopper is depressurized from the high operating pressure to nearly atmospheric, or high-pressure vent gas, is typically recycled to the process. However, the remaining low-pressure vent gases may be vented directly to the atmosphere in some baseline plants. Data obtained from such a plant utilizing Lurgi gasifiers indicate an emission factor of 3.8×10^{-2} lb/ton coal.

Incineration or recycle after compression may be used to control emissions from this source.

4.4.3.4 Vents From Indirect Liquefaction Processes--

Synthesis processes used in indirect coal liquefaction produce purge gas streams which, because they contain significant amounts of unreacted synthesis gases as well as some VOC, may be routed to an auxiliary by-product reactor, such as a methanation unit. Methanation, in turn, processes a CO_2-rich vent containing the unreacted VOC. The emissions factor for this source can be estimated at 0.03 lb VOC per ton of gas to by-product methanation. At the low concentrations expected to be encountered, it may not be cost-effective to route this stream to an incineration device for additional VOC control.

4.4.3.5 Direct Liquefaction Vacuum Pressure Separator Vent Gas--

The direct liquefaction module includes the atmospheric and vacuum distillation equipment used to separate the liquefaction reaction products from the spent solids. A potential point source of VOC emissions in an uncontrolled liquefaction module would be the vent gas from the vacuum separator. This stream will likely contain large concentrations of volatile organics. Based on information in the EDS design report (reference 7) an uncontrolled emission factor of 1 lb of VOC per ton of coal feed to liquefaction was estimated. Since the uncontrolled venting of this stream would result in large VOC emission rates, it is likely that it would be controlled by routing it to a boiler or incinerator.

4.4.3.6 Oil Shale Retorting Preheater Vent--

Most above-ground oil shale retorting processes produce a VOC-containing flue gas from the shale preheating operation. The amount of VOC emissions produced appears to depend heavily on the particular retorting process employed (references 8, 9 and 10). An average emission factor is 0.04 lb VOC per ton of shale. Emission control by incineration may be needed in some cases.

4.4.3.7 Acid Gas Removal Vent--

Acid gas removal processes are needed in synfuels plants to reduce the concentrations of such compounds as carbon dioxide and hydrogen sulfide in product gas streams. Several processes can be designed to operate in either selective or non-selective modes. Selective operation produces two separate acid gas streams, one containing most of the carbon dioxide and the other containing most of the hydrogen sulfide. Non-selective removal produces a single acid gas stream. For selectively operated designs, the carbon dioxide-rich stream may be vented directly to the atmosphere in an uncontrolled plant.

Based on data from the Kosovo gasification complex (reference 6), an uncontrolled emission factor of 2.7 lb VOC per ton of coal gasified was calculated. At this rate, control by incineration may be needed.

4.4.3.8 Wastewater Solvent Extraction Vents--

The extraction of process wastewater for the removal of phenolic compounds, as by the Phenosolvan process, results in a number of vent streams which may contain VOC. Based on Kosovo data (reference 6) it appears that these vents are low-volume, low VOC-concentration streams which will not add significantly to the overall VOC emissions from a synfuels plant.

SECTION 5

DESCRIPTION OF REFINERY MODULES

This section includes a description of each of the refinery modules from which the VOC emission model is comprised. The primary function of this section is to provide a detailed definition of each module so that the user can confidently assign one (or more) modules to represent any significant refinery process. That definition includes a brief description of the process function, module inputs/outputs, and a list of specific refinery processes represented by the module.

In addition to documenting the module definition, each module discussion specifies the sources of data upon which the default values were based. Some general observations concerning the default values can be explained once here to avoid repetition in each module. The default values for the populations of process fittings are averages of counts taken from references 11 and 12. The specific table numbers and/or unit designations used are given with each module. There has been some question over the default populations of open-end lines, which may underestimate the population by a factor of three. The defaults were left as is because of a lack of supporting data for the higher populations, but it should be noted that they may be low. The distribution of fittings into the various service categories is based on data in reference 11, pump data in reference 12, and engineering judgement. In general, the percentage of sources in hydrocarbon gas and hydrogen service are taken directly from reference 11 and supplemented and/or modified using engineering judgement. Pump service distributions are given in both references 11 and 12, and the distribution of other sources between light liquids and heavy liquids is in proportion to the pump service distribution. The default values for combustion requirements are also based on an average of data in references 11 and 12. The fuel mix default is specified as gas for all process modules based on personal observations and engineering judgement.

The default values for module capacity relative to refinery crude capacity are based on either reference 13, reference 14, or an average of the two values. The default values for wastewater generation are taken from reference 5. Other default values are less general in nature and are discussed with each appropriate module.

5.1 REFINERY PROCESS MODULES

The hundreds of possible refinery processes have been condensed into 27 process modules. Each of these modules is defined in this section in the order they were listed in Table 4-1.

Atmospheric Crude Distillation

The atmospheric crude distillation module is defined to include crude desalting, a heat exchange network, the atmospheric charge heater, the atmospheric column, the side stream stripper, and all associated equipment. Facilities for recovering LPG from the non-condensible overhead gases are not included in this module (see Light Ends Recovery and Distillation). The input to this module is primarily crude oil, but that may be supplemented by recovered oil, slop oil, condensate, butanes, etc. The products of this module include a broad range stocks, including LPG-rich OH gas, straight run naphtha, a middle distillate cut (kerosene, AvJet, etc.), one or more atmospheric gas oil cuts, and a reduced crude (atmospheric column bottoms). Almost all of the products undergo further processing by other modules.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-3 from reference 11 and units X34, X32, and X12 from reference 12. The latter two units had to be modified to separate the atmospheric and vacuum distillation sections.

Vacuum Crude Distillation

This module is defined as the vacuum charge heater, the vacuum column, the vacuum-producing equipment (steam ejectors, mechanical pumps, and barometric or surface condensers), and all associated equipment. The input to this module is reduced crude from the bottom of the atmospheric column, and the outputs are one (or more) vacuum gas oil cuts and a vacuum resid. Depending on the type of crude processed and the cuts, the vacuum gas oils may be used as lube oil feedstocks, cracking feedstocks, or in fuel oil blends.

The defaults for this module were calculated according to the procedures outlines at the beginning of this section. Most of the default data are based on Table F4-6 from reference 11 and units X12 and X32 from reference 12. The latter two units had to be modified to separate the atmospheric and vacuum distillation sections.

Naphtha Hydrotreating

This module is designed to reduce the sulfur content of naphthas (straight run or cracked) prior to reforming or gasoline blending. The module is defined to include hydrotreating reactor(s), fired heater(s), product stripper, hydrogen compressor(s), and all associated equipment. The inputs are naphthas from crude distillation or cracking processes, and the output is hydrotreated naphtha. Some trade names which might be represented by this module include Unifining, Ultrafining, Unionfining, Thermal Naphtha Hydrotreating, Pyrolysis Gasoline Hydrotreating, Pyrolysis Distillate Hydrogenation, Hydrofining, Hydrotreating, Hydrogenation of Pyrolysis Naphtha, and DPG Hydrotreating. Each of these processes (and possibly others) have differences in process conditions, types of feedstocks, and severity of hydrotreating. The key to the module definition is that the unit must be involved in the hydrogen treating of feedstocks similar in volatility to petroleum naphthas.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-43 from reference 11 and units X2 and X44 from reference 12.

The light liquid/heavy liquid distributions from reference 1 were adjusted to account for a naphtha feedstock.

Middle Distillate Hydrotreating

The potential functions for this module include desulfurization, denitrification, saturation of aromatics, smoke point improvement, etc. The key to the module definition is the use of hydrogen treating on a feedstock in the middle distillate volatility range (kerosene, AvJet, diesel, etc.). This module includes catalytic reactor(s), fired heater(s), product stripper, hydrogen compressor(s), and all associated equipment. Some trade names which may be represented by this module include Distillate Hydrodesulfurization and Smoke Point Improvement, Hydrotreating, Hydrofining, Smoke Point Improvement, Ultrafining, Unionfining, and Unisar.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-43 from reference 11 and units X5 and X6 from reference 12.

Gas Oil Hydrotreating

The functions and definition of this module are similar to the previous two hydrogen treating modules, but the charge stocks would be atmospheric gas oils, vacuum gas oils, and lube oil stocks. Some trade names which may be represented by this module include Distillate Hydrodesulfurization and Smoke Point Improvement, Duotreat Oils, Ferrofining, Fuel Hydrodesulfurization, GO-fining, Gulfining, Gulfinishing, HGO-HDS, Hydrotreating, Hydrofining, Hydrogen Finishing, "Lube, Wax, and Specialty Oil Hydrotreating," Lube Oil Hydrotreating, Ultrafining, Unionfining, VGO and DAO Hydrotreating, and Wax Hydrofinishing.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-3G from reference 11 and units X18, L16, L33, and N19 from reference 12.

Resid Hydrodesulfuriation

The functions and definitions of this module are similar to the previous three modules, but the charge stock is either vacuum resid or reduced crude. Some trade names which may be represented by this module include RCD Union, RDS and VRDS Hydrotreating, Resid HDS, and Residfining.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-33 from reference 11 and unit X14 from reference 12.

Catalytic Reforming

The primary objective of catalytic reforming is to increase the octane numbers of gasoline blending stocks. Charge to the catalytic reformer is desulfurized naphtha from hydrotreating, and the product is reformate which may be split into a light and heavy cut. The module definition includes charge heater(s), catalytic reactor(s), product separators, hydrogen compressor(s), product stabilizer (fractionator), and all associated equipment. Some trade names which are represented by this module include Magnaforming, Platforming, Powerforming, Rheniforming, and Ultraforming.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-48 from reference 11 and units X4, X13, and X24 from reference 12.

Aromatics Extraction

The primary function of this module is to concentrate the aromatics in reformate for use as a high octane blending stock or as a petrochemical feedstock. The module is defined to include an extraction column, a stripper, solvent recovery facilities, and all associated equipment. Some trade names which are represented by this module are Sulfolane, Udex, Tetra, Morphylane Extractive Distillation, and Morphylex Extraction.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-7 from reference 11 and unit X25 from reference 12.

Catalytic Cracking

This module charges a variety of gas oil stocks and catalytically cracks them into a full range of products, with the emphasis normally on increased production of gasoline blending stocks. Most of the units represented by this module are Fluid Catalytic Crackers, but a few of the Thermofor (TCC) and Houdry (HCC) units are still in operation. The definition of this module includes the reactor, regenerator, charge heater, heat exchange network, main fractionator, and all associated equipment. This module does not include facilities for recovery of olefins from the product separator gas or downstream fractionation (see Light Ends Recovery and Fractionation). Some trade names which are represented by this module include Flexicracking, Ultra-Orthoflow, Heavy Oil Cracking, and Fluid Catalytic Cracking.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-25 from reference 11 and unit X26 from reference 12.

Hydrocracking

This module has the same basic function as the catalytic cracking module, but the cracking reaction is carried out at high pressures and in the pressure of an abundance of hydrogen. The definition of this module includes catalytic reactor(s), product separator(s), hydrogen compressor(s), main fractionator, naphtha stabilizer, and all associated equipment. Some trade names which are represented by this module include Isocracking, CANMET Hydrocracking, H-G Hydrocracking, H-Oil, HC Unibon, Hycracking, Hydroconversion, L-C Fining, and Hydrocracking.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-31 from reference 11.

Thermal Cracking and Visbreaking

This module represents a variety of processes which crack gas oil stocks thermally (without a catalyst) and produce a range of liquid products (not coke). The module is defined to include charge heater(s), reactor(s), main fractionator, and all associated equipment.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-17 from reference 11.

Delayed Coking

The delayed coking process is similar to thermal cracking, except that coke is produced as one of the products. The module is defined to include charge heater(s), coke drums, fractionator, stripper, and all associated equipment.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-10 from reference 11 and unit X28 from reference 12.

Fluid Coking

Fluid coking is similar to fluid catalytic cracking except that finely divided coke particles replace the catalyst and coke is produced as a product. The most important variation on this process is Flexicoking, in which the product coke is gasified. This module is defined to include reactor heater steam generator, fractionator, gasifier (optional), and all associated equipment.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-13 from reference 11.

Light Ends Recovery and Fractionation

The function of this module is the removal of propylene and heavier hydrocarbons from a gas phase stream, and the separation of these recovered hydrocarbons into fractions appropriate for further processing or blending. The recovery process is typically accomplished by a circulating oil absorber/stripper. The fractionation section may include a demethnizer, deethanizer, depropanizer, debutanizer, butane splitter, naphtha stabilizer, etc. These units may exist independently, taking feed gas from many different units, or they may be dedicated to a single unit such as an atmospheric distillation column, a fluid catalytic cracker, or other cracking processes. Although this common technology has no trade names associated with it, it may be called a gas plant, LPG plant, light ends recovery plant, absorption plant, or other similar names.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table 5-17 from reference 11 and units X1 and X3 from reference 12.

Other Miscellaneous Fractionation Units

Fractionationation (or fractional distillation) is the most common form of separation used in refineries. Some fractionation columns are an indispensable part of each refinery process, and these dedicated columns were included in the appropriate module definitions. Other fractionation columns exist independently or are an optional part of another module, and it is these other fractionation facilities which are represented by this module. Each such facility will typically include several distillation columns, a heat exchange network, possibly a fired heater, and other associated equipment. They may be called by such names as naphtha stabilizers, naphtha splitters, steam stills, rerun stills, slop oil stills, etc.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on units X10, X11, X17, X35, X39, and M30 from reference 12.

Alkylation

The function of this module is the formation of a high-octane gasoline stock by combination of isobutane with various light olefins (normally butylene or propylene). The process is carried out at low temperatures and is catalyzed by either sulfuric or hydrofluoric acid. The module typically includes reactor(s), refrigeration system, several distillation columns, and all associated equipment. The name alkylation is standard, but it may be proceeded by the type of acid used as a catalyst (i.e., sulfuric acid alkylation or HF alkylation).

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-54 from reference 11 and units X15 and X48 from reference 12.

Polymerization

This module also forms a gasoline stock from light ends, but in this case by combining several olefin molecules (typically the trimer of propylene). This is a gas phase process which is catalyzed by phosphoric acid. The module is defined to include reactors, compressors, distillation columns, and all associated equipment. This module may be called simply the polymerization unit (often shortened to "POLY"), or it may be called propylene polymerization or the polymer gasoline unit. This module is differentiated from other polymerization in the petrochemical area by the fact that its product is a gasoline stock.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on X16 from reference 12.

Isomerization

The function of isomerization is the rearrangement of a hydrocarbon molecule (from one isomer to another). The most common applications are the isomerization of normal butane to isobutane (to increase feed for alkylation) and the isomerization of mixed C_5/C_6 hydrocarbons to increase their octane number. This unit typically includes reactor(s), compressor(s), distillation columns, and all associated equipment. The name isomerization is normally used, but it may be abbreviated to "ISOM" or preceded by a feedstock designation (C_4 Isomerization).

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-61 from reference 11.

Lubes Processing - Volatile Organic Solvents

Lubricating oils are typically of low volatility, and their processing alone contributes very little to atmospheric VOC emissions. Some of the solvents used in treating lube oils, however, are quite volatile, and this module represents those lube oil processes which involve volatile organic solvents. This module represents a large number of processes, and it is difficult to establish a firm module definition, but the typical processes will include extraction/contacting vessels, separation vessels, filters, solvent recovery facilities (water washes, strippers, and distillation columns), and all associated equipment. The generic names of some processes represented by this module include propane deasphalting, propane dewaxing, propane deresining, and solvent dewaxing, while trade names are included such as Demex, Dilchill, Residunm Oil Supercritical Extraction (ROSE), Solvent Decarbonizing, and Solvent Deasphalting.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table 5-17 from reference 11 and unit X42 from reference 12.

Other Lubes Processing

This module includes all lube oil processes not covered in previous modules (those with volatile solvents and lube oil hydrotreating). There are too many trade names involved to effectively list them here, so this module is defined to cover those lube oil processes not specifically listed in other modules.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on units X29 and X30 from reference 12.

Asphalt Production

The processes represented by this module are involved in treating residua from vacuum or atmospheric distillation to produce a variety of asphalt-based products. Some of the processes covered include asphalt oxidizing, asphalt emulsifying, Dubbs pitch, and 200°F softening point unfluxed asphalt.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Section F4.7.1.1 from reference 11 and unit L-50 from reference 12.

Hydrogen Production

Modern refineries rely heavily on the use of hydrogen in treating a variety of fuels and lubricants, and the demand often exceeds the traditional source of supply - the catalytic reformer. This module represents units designed to produce supplemental hydrogen to balance the demand. The two primary processes in use are steam reforming and partial oxidation. A variety of feedstocks may be used, from natural gas to fuel oils.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on Table F4-64 from reference 11 and units X7 and X8 from reference 12.

Gasoline Treating

Naphthas are often treated to remove or reduce their mercaptan sulfur content, to improve their storage stability, and to reduce gum formation. This module represents a variety of units performing one or more of these functions, including inhibitor sweetening, Merox, mercapfining, Petreco Locap, Linde sweetening, Doctor Treating, and caustic treating.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on units X31, M29, L60, and N8 from reference 12.

Other Product Treating

This module contains processes used in treating fuels heavier than gasoline. Some of the processes have the same name as gasoline treating processes, and the feedstock must be used to decide which module applies. Some processes represented by this module include clay treating, Linde Treating, copper chloride treating, and salt treating.

The defaults for this module were calculated according to the procedures outlined at the beginning of this section. Most of the default data are based on units X19 and M8 from reference 12.

Olefins Production

The production of olefins (primarily ethylene and propylene) by pyrolysis of various hydrocarbon feedstocks is the source of the basic building blocks for much of the petrochemical industry. The feedstocks are typically a blend of ethane/propane, a naphtha, or a fuel oil, and olefins plants are often associated with refineries because of the easy availability of these feedstocks. These are extremely large units which typically include many cracking furnaces, large compressors, many distillation columns, refrigeration system(s), and all associated equipment. Because of their size, these units are often broken down into sections (such as pyrolysis, quench, compression, and fractionation). This module is defined to include all these section, but it does not include any further processing of the basic olefins products (such as polymerization or butadiene recovery). Note: use the special petrochemical calculation sheet for this module.

The defaults for this module were calculated similar to the procedures outlined at the beginning of this section. Most of the default data came from reference 16, units 2, 4, and 11. Some utilities data were taken from reference 17. The capacity default was based on the percentage of refinery output going to petrochemical feedstocks (reference 14), and the use of engineering judgment in calculating the portion of those petrochemical feedstocks going to onsite olefins plants.

Other Volatile Petrochemicals

Many other petrochemicals are produced in conjunction with refining because of feedstock availability, and this module represents those processes which perform a significant amount of processing and hydrocarbons with a volatility equal to or greater than naphtha. Because of the variety of processes involved, it is difficult to state a precise definition for this aggregate module. The best definition is a listing of the processes represented, which would typically include butadiene, alpha olefins, aromatics (benzene and toluene), cumene, cyclohexane, aliphatics, linear paraffins, heptene, MEK, MIBK, Ethyl Amyl Ketone, MTBE, tertiary amylenes, acetone, isobutylene, and hydrodealkylation of aromatics. Note: use the special petrochemical calculation sheet for this module.

The defaults for this module were calculated similar to the procedures outlined at the beginning of this section. Most of the default data came from Table F4-63 from reference 11, unit X43 from reference 12, and units 5, 6, 12, 31, and 32 from reference 16. The default capacity was calculated similar to that described for the olefins production module.

Other Low Volatility Petrochemicals

This module represents the remainder of the petrochemical processes associated with refineries that do not fit into one of the two previous categories. These processes primarily handle materials with a volatility equal to or less than kerosene. Some typical processes in this category would include naphthalenes, xylenes, mineral spirits, octyl formal alkylate, styrene, phthallic anhydride, nonene, diallylamine, polyisobutylene chloride, oxoalcohols, phenol, cresylic acid, naphthenic acids, butyl alcohols, pentoxone, sodium sulfonates, tertiary butyl toluene, most polymers, carbon black, furfural, most catalysts, mesityl oxide, isophorone, oxidates, gasoline additives, and lube oil additives. Note: use the special petrochemical calculation sheet for this module.

The defaults for this module were calculated similar to the procedures outlined at the beginning of this section. Most of the default data came from unit X27 from reference 12, and the descriptions of styrene, phthalic anhydride, and polyethylene production given in reference 18. The default capacity was calculated similar to that described for the olefins production module.

5.2 AUXILIARY MODULES

The following list of seven modules represents those auxiliary facilities which are necessary to the support of a refinery (or a synfuels plant), but do not fit within the definitions of any specific process module.

Boilers

This module includes those independent combustion units dedicated to the production of process steam and/or electricity. Special boilers that are dedicated to a given process unit are not included in this module, but rather in the appropriate process module (i.e., CO boilers are included in the Catalytic Cracking module). This module has its own calculation sheet.

The boiler default values were calculated from data presented in references 19 and 20. The fuel mix was taken primarily from reference 19, and the default capacity was based on an average of data in references 19 and 20.

Blowdown System and Flares

This module is defined to include the entire blowdown system and flare system for the plant. This module has its own calculation sheet.

The only default data for the blowdown system and flares is the overall plant emission factor for flares from reference 21.

Wastewater Treating

This module is defined to include the entire wastewater collection and treating system for the plant. The primary sources of VOC emissions from wastewater treating, and the only sections with specific emission data available, are the oil-water separator (OWS) and the dissolved air flotation units (DAF). Emissions are calculated individually for each OWS and DAF using the calculation sheet dedicated to this module.

The default wastewater flow rate is based on the effluent flow model presented in reference 15. The other default data are based on values developed in support of NSPS for refinery wastewater systems and documented in reference 22.

Sludge/Solids Handling

A variety of waste products are produced in refineries and synfuels plants. This module represents any on-site disposal processes used for these wastes, including land farming, land filling, and ponding. The characterization of VOC emissions from these processes has not progressed to the same degree as the other processes covered in this model. Some theoretical models have been proposed to estimate evaporative emissions from waste disposal operations, and some of these models have been included in this module for completeness. The inputs required to estimate emissions using these models are so complex and theoretical, however, that it is beyond the scope of this study to provide complete defaults, as has been done for the other modules. If the user has relied heavily on default values for other modules, then the contributions of this module may be neglected without significantly affecting the accuracy of the total VOC emission estimate. If the user has supplied detailed input data to the previous calculations, then it is probable that the data required as input to this module can also be developed.

Crude and Product Storage

The evaporative emissions from storage tanks is one of the larger sources of VOC in refineries. This module contains calculation procedures for the two most common types of tankage - fixed roof and floating roof tanks. Pressurized tanks are omitted because they have negligible emission potential, and variable vapor space tanks because they are used infrequently. Tanks with vapor recovery systems should be calculated as fixed roof tanks, and then reduce the calculated emissions in proportion to the recovery efficiency of the control system. This module has its own series of combined calculation and default sheets.

The equations for calculating tank emissions are taken from reference 21, and that source also presents many tables, graphs, and nomographs to use in determining the appropriate input data. When it seemed appropriate, a final default was selected from the available sources based on engineering judgment.

Default values for total plant storage capacities were based on average stock hold-up times calculated from reference 12. The default stock production rates relative to crude are the national average values for 1981 given in reference 14. The average tank sizes by stock are based on data from reference 12. The tank dimension defaults are also based on typical data from reference 12, plus some "rule of thumb" values from reference 23.

Cooling Towers

VOC emissions from cooling towers occur as a result of leakage of process fluids into the circulating cooling water in heat exchangers. This module represents all the cooling towers in a plant on a combined basis. This module has its own combined calculation and default sheet.

The only default value used in the cooling tower calculation is the default capacity relative to the crude charge rate. This value was calculated from the two emission factors given in reference 21. It would have been preferable to link cooling water demand to the module distribution, but insufficient data were found to establish that relationship.

Product Loading Operations

VOC emissions occur during the transfer of products from storage tanks to the various vehicles used to transport them to market. This module includes loading facilities for rail cars, tank trucks, barges, ocean barges, and marine tankers. This module has its own combined calculation and default sheet.

The default values for the amounts of each stock loaded into various means of transportation were calculated using average product yields from reference 14, average distributions of each stock by various vehicles from reference 24, and engineering judgment. The default emission factors were selected to represent typical operations and/or a value near the middle of the range of variation.

SECTION 6

DESCRIPTION OF SYNFUEL PLANT MODULES

This section includes a description of each of the synfuels plant modules which has been incorporated in the VOC emission model, including a brief description of the process function, module inputs/outputs, and specific processes represented by the module. The sources of data used to arrive at the default values for each module are also documented in this section.

6.1 COAL PREPARATION (THERMAL DRYING)

Thermal drying is the only coal preparation step included in the VOC emission model. Other steps such as coal crushing, grinding, washing, etc., although they may represent significant potential sources of particulate emissions, do not produce volatile organics. Thermal drying includes processes which contact coal with hot gases produced by fuel combustion or with steam. Dryers may be batch or continuous units, contacting may take place in fixed bed, fluid bed, or entrained bed devices.

The module receives moist coal from previous preparation steps and produces dried coal as the output. Flue gas or autoclave vent gases are the primary potential source of VOC emissions from the module. The only VOC emission rate data obtained were for a Fleissner autoclave dryer system used at the Kosovo gasification complex in Yugoslavia (reference 6). Variations due to differences in heating rates and temperatures and coal volatility may be expected.

Wastewater generation default rates for Fleissner dryers were based on a moisture moist balance expression.

6.2 SLURRY DRYING

Slurry drying is a step used in the Exxon Donor Solvent (EDS) process to reduce the amount of coal moisture carried through the process (reference 7). Crushed coal is fed into slurry tanks where it is mixed with hot recycle solvent. This contact results in partial devolatilization of the coal, with inert gases from coal feeding, moisture and some light organics being the primary constituents of the dryer vent gas. The coal slurry is sent to the liquefaction module.

Default values for the populations of process fittings as a function of the number of pumps and pump seals were obtained using data in reference 11, pump data in reference 12 and engineering judgment. Pump counts, service distributions, and pressure vessel counts were taken from the Exxon Design Report (reference 7). Point source emissions data were also taken from reference 7. Wastewater generation rates were based on a moisture balance over the slurry dryer, with defaults for dried coal moisture content and inlet coal moisture levels from references 7 and 25, respectively.

6.3 COAL GASIFICATION/GAS COOLING

This module encompasses the coal feed system, coal gasification reactors, ash removal and handling system, and raw gas quench and cooling systems. A large number of possible gasifier types exists; they may conveniently be grouped according to bed type as fixed-bed, fluid-bed, and entrained-bed gasifiers. Ordinarily, fluid-bed and entrained-bed gasifiers operate at higher temperatures than those in fixed-bed gasifiers. These higher temperatures result in essentially complete destruction of devolatilization products such as tars and oils and also favor low concentrations of hydrocarbon gases. Therefore, it is reasonable to expect that VOC emissions from the gasification module will be negligible for fluid- and entrained-bed gasifiers (such as U-Gas, Westinghouse, Koppers-Totzek, and Texaco). Fixed-bed processes may be typified by the Lurgi process.

Gasification inputs include coal, oxygen (or air), and steam, with spent ash or slag and hot crude product gas as the primary outputs. Gas cooling results in the formation of quench liquor (unreacted steam, coal moisture, and water formed as a result of gasification reactions) and (possibly) condensed organics.

Default values for populations of process fittings as a function of the number of pumps and pump seals were obtained using data in reference 11, pump data in reference 12, and engineering judgment. Pump counts, service distribution, and pressure vessel counts were taken from reference 26. Point source emission defaults were taken from reference 6. Wastewater generation rates were based on a gasifier oxygen balance, with default factors from a number of references for several gasifier types (references 27, 28 and 29) and Radian internal sources.

6.4 METHANOL SYNTHESIS

The methanol synthesis module includes syntiesis reactors, separators and expansion vessels, methanol condensors, and methanol purification (distillation) towers. In addition, it is assumed that synthesis purge gas is routed to a methanation system, including catalytic reactors, knockout drums, CO_2 removal equipment, and dehydration equipment. A number of methanol synthesis processes are available from commercial vendors, including Lurgi, ICI, Chem Systems, and others. Methanol synthesis receives cleaned synthesis gas and produces methanol, purge gas, and wastewater as major outputs. Auxiliary methanation receives the purge gases and produces methane, a high quality wastewater, and a CO_2-rich vent stream.

Default values for the populations of process fittings as a function of the number of pumps and pump seals were obtained using data in reference 11, pump data in reference 12, and engineering judgement. Pump counts, service distributions, and pressure vessel counts were taken from a conceptual design report (reference 30). Point source emissions default values were based on Radian mass balances. Wastewater generation rates were based on water balance considerations and Radian mass balances.

6.5 FISCHER-TROPSCH SYNTHESIS

The Fischer-Tropsch process is a catalytic process for the production of a variety of liquid products from synthesis gas. The module included Fischer-Tropsch synthesis reactions, heat exchange and crude produce separation, and auxiliary methanation (as described in the methanol synthesis module).

Default values for the populations of process fittings as a function of the number of pumps and pump seals were obtained using data in reference 11, pump data in reference 12, and engineering judgement. Pump counts, service distributions, and pressure vessel counts were taken from a conceptual design report (reference 31). Point source emissions default values and wastewater generation rates were based on Radian mass balance calculations.

6.6 MOBIL M SYNTHESIS

The Mobil Methanol to Gasoline Process converts input methanol to gasoline-range hydrocarbons and some LPG, in two catalytic reaction stages. The module includes methanol synthesis, methanol conversion, and crude product separation. In addition, axuiliary methanation as described in the methanol synthesis module is included.

Default values for the populations of process fittings as a function of the number of pumps and pump seals were obtained using data in reference 11, pump data in reference 12, and engineering judgement. Pump counts, service distributions, and pressure vessel counts were taken from a conceptual design report (reference 32). Point source emissions and wastewater generation default values were based on Radian mass balance calculations.

6.7 DIRECT LIQUEFACTION

The direct liquefaction module serves to convert slurried coal and hydrogen to a variety of gaseous and liquid products which are separated from each other and from the spent coal char in atmospheric and vacuum distillation columns. Several of the leading direct liquefaction processes which have been developed in recent years are the Exxon Donor Solvent (EDS) processes, the H-Coal process, and the two versions of the Solvent Refined Coal process (SRCI and II).

Default values for the populations of process fittings as a function of the number of pumps and pump seals were obtained using data in reference 11, pump data in reference 12 and engineering judgement. Pump counts, service distributions, and pressure vessel counts were taken from an EDS design report (reference 7). Combustion defaults were taken from data in reference 7 and 33. Point source emissions defaults were taken from reference 7. The wastewater generation rate expression was based on oxygen balance around the liquefaction module, with defaults from references 7 and 25.

6.8 ABOVE-GROUND OIL-SHALE RETORTING

The oil-shale retorting module includes shale preheating, retorting, and spent shale cooling. Some differences exist between processes in the particular ways these functions are accomplished. Leading processes which have been developed include TOSCO II, Lurgi-Ruhrgas, Paraho, and Union B retorting. The module input is raw shale, while outputs include preheater flue gas, spent shale, and raw product gases and liquids.

Insufficient process data were available to allow estimation of process fugitive VOC emissions using source counts and emissions factors. An overall emission factor based on the shale processing rate was developed using data in various shale oil process Pollution Control Technical Manuals (references 34, 35 and 36). Combustion emissions, point source, and wastewater generation default values were obtained from the PCTM's and reference 37.

6.9 ACID GAS REMOVAL

Acid gas removal processes act to reduce the concentrations of acid gases such as carbon dioxide and hydrogen sulfide, among others, to downstream end users or synthesis processes. This module receives cooled raw product gas or various four gas streams, removes the acid gases to the desired levels, and produces as outputs the cleaned gas and one or more streams which contain the removed acid gases. The module included columns for contacting gas with the acid gas removal solvent, solvent regeneration equipment, and prewash columns. Leading AGR processes include Rectisol, various amine-based processes (MEA, DEA, DMEA, etc.), and Selexol among others.

Default values for the populations of process fittings as a function of the number of pumps and pump seals were obtained using data in references 11 and 26, pump data in reference 12, and engineering judgement. Pump counts, service distributions, and pressure vessel counts were taken from reference 26. Point source emissions defaults were taken from data in reference 6. Wastewater generation default rates were taken from Radian mass balances based on the use of the Rectisol process on Lurgi gasifier raw product gas.

6.10 OIL-SOLUBLE ARSENIC REMOVAL

The purpose of this module is to reduce the concentration of arsenic in hydrocarbon liquids. This module may be useful in oil shale plants where high arsenic levels may be found in the shale oil sent to upgrading facilities (reference 33). No process information was found from which to derive VOC emissions default values. It is anticipated that the emissions from this module will be insignificant compared to the overall plant emission rate.

6.11 WASTEWATER SOLVENT EXTRACTION

The purpose of this module, the best known example of which is the Phenosolvan process, is to reduce the concentrations of organic contaminants (especially phenols) in process wastewater to levels compatible with the requirements of downstream wastewater treatment limits (such as biological oxidation). The module receives wastewater to be extracted and produces treated effluent and a crude phenol stream.

Default values for the populations of process fittings as a function of the number of pumps and pump seals were obtained using data in references 11 and 26, pump data in reference 12, and engineering judgement. Pump counts, service distributions, and vessel counts were taken from reference 26. Reference 6 data indicated that point source emissions could be neglected.

SECTION 7

ESTIMATING VOC EMISSIONS FROM REFINERIES AND SYNFUEL PLANTS

This section provides a discussion of how the reader can obtain an estimate of VOC emissions from a refinery or synfuel plant using this manual. Section 7.1 is a discussion of the calculational procedures to be followed in estimating VOC emissions. Section 7.2 shows how to apply overall plant emission factors to obtain emission estimates when all that is known about a plant is its general type and capacity. Section 7.3 gives examples of the application of the calculational procedures for two synfuels plants and two refineries.

7.1 CALCULATIONAL PROCEDURES FOR ESTIMATING VOC EMISSIONS

This section outlines the procedures to be followed by the user of this manual to obtain an estimate of VOC emissions from a refinery or synfuels plant. The procedure consists of four steps:

- Select the appropriate modules,
- Obtain the necessary calculation worksheets,
- Provide the necessary information for each module,
- Perform the calculations

Each of these steps is described in more detail in the following text.

Select the Appropriate Modules

The user must first divide the plant into suitable process and auxiliary modules. Descriptions of the various refinery and synfuel modules included in the VOC emission model are found in Sections 5 and 6, respectively. This step may require the user to make judgements in some cases as to which modules best describe the plant in question.

If the user does not have enough information available about the plant to be able to choose modules, but merely knows the general kind of refinery or synfuel plant and its size, a rough estimate of the overall plant VOC emissions may be obtained by using the emission factors developed in Section 7.2 of this manual.

Obtain the Necessary Worksheets

After the user has decided which modules to use to describe his plant, he must gather the emission calculation worksheets needed for each module. A supply of worksheets of each type is provided in Appendix B of this manual. It would probably be advisable to make photocopies of the required worksheets so that the manual can be used to perform future estimates.

Provide the Necessary Information

The reader next supplies the information requested for each set of module worksheets. The types of information needed include the population of each fugitive emission source type and fluid service, fuel types and boiler/heater duties; point source vent flow rates, VOC concentrations and molecular weights or emission factors; tank information, including size, throughput, paint and seal characteristics, etc.; wastewater treatment rates and so on. The specific data needed are spelled out on the worksheets.

If not enough is known about the plant in question to fill in the blanks, the reader can use the default listings found in Appendix C. The sources of the default values are discussed in Sections 5 and 6. It is important to note that the default source populations and other information are for one equipment train. If the plant in question has identical multiple equipment trains in a given module, the default values must be multiplied by the number of trains in order to obtain a total for the plant.

A calculation sheet should be filled out for each process unit in the subject plant. Where some modules have been structured to represent multiple types of process units, the calculation sheet for that module should be repeated for each plant process unit represented.

Perform the Calculations

Once the required information has been provided on the worksheets, the user may proceed to perform the calculations. The number of fugitive emissions sources must be multiplied by the appropriate emission factors for the module in question. Three different sets of emission factors are included in the module. These include factors for refinery, petrochemical, and some synfuels modules, as discussed in Section 4.

The estimated emissions may be summarized in two instructive ways. First, totals for each module may be found; a comparison of the various modules gives an indication of which modules produce the most emissions. Control measures may then be applied to the biggest emitters first. Alternatively, all of the emissions from a given source type may be added together and compared to those from other source types. Since control measures are the same for a given source type, regardless of the module in which it appears, this technique can be used to quickly assess the emission reduction possible by implementing a certain control measure. Total VOC emissions for the plant are equal to the contributions from all of the modules or from all of the various source types.

Examples of the application of the calculational procedures are given in the next two sections, 7.2 and 7.3.

7.2 APPLICATION OF MODEL TO BASIC REFINERIES AND SYNFUELS PLANTS

Throughout the VOC emission model, a substantial effort has been made to provide multiple levels of default, so that the model will be flexible enough to give each user the best estimate possible. This section presents another higher level default, which effectively reduces the required input data to the type of plant and its capacity. This was accomplished by fully characterizing a number of model plants, and then calculating their emissions using all default values. The estimates resulting from this process are obviously very rough, but considering the minimal time required to generate them, this may be an attractive route in some preliminary investigations.

7.2.1 Basic Refinery Models

It may be useful to be able to quickly make a rough estimate of the total VOC emissions for a given refinery when very little input data is available. This section presents a set of refinery categories for which such quick estimation models have been developed. These rough models are really the ultimate default level, since all the user must do is select the category of refinery and plug in its crude capacity.

The American Petroleum Institute has developed a classification system for refineries based on processing complexity and product slate. The five refinery categories that result are:

- Type A - Topping;
- Type B - Topping and Cracking;
- Type C - Topping, Cracking, and Petrochemical;
- Type D - Topping, Cracking, and Lubes; and
- Type E - Integrated.

An appropriate set of modules was selected for each of the above categories, and the emissions were calculated using all default values. Some of the emissions are expressed in an absolute form (lb/day), while others must be expressed relative to the crude charge rate (lb/10^3 Bbl Crude).

The Type A (or topping) refinery includes atmospheric distillation, vacuum distillation, naphtha hydrotreating, catalytic reforming, middle distillate hydrotreating, and asphalt processing. The emissions from a Type A refinery can be estimated by:

$$\text{Emissions (lb/day)} = 4{,}024 + (82.3)(\text{Crude Rate in } 10^3 \text{ BPD})$$

The average Type A refinery has a crude capacity of 14,000 BPSD.

The Type B (or cracking) refinery has all the modules in the Type A plus fluid catalytic cracking, hydrocracking, thermal cracking, delayed coking, gas oil hydrotreating, alkylation, and aromatics extraction. The emissions from a Type B refinery can be estimated by:

$$\text{Emissions (lb/day)} = 13{,}649 + (82.4)(\text{Crude Rate in } 10^3 \text{ BPD})$$

The average Type B refinery has a crude capacity of 66,000 BPSD.

The Type C refinery has all the modules in Type B plus some primary and secondary petrochemicals, such as olefins, BTX, cyclohexane, cumene, styrene, ketones, alcohols, etc. The emissions from a Type C refinery can be estimated by:

$$\text{Emissions (lb/day)} = 25{,}339 + (83.1)(\text{Crude Rate in } 10^3 \text{ BPD})$$

The average Type C refinery has a crude capacity of 150,000 BPSD.

The Type D (or lubes) refinery has all the modules in Type B plus modules for processing lubricating oils. The emissions from a Type D refinery can be estimated by:

Emissions (lb/day) = 24,455 + (86.0)(Crude Rate in 10^3 BPD)

The average Type D refinery has a crude capacity of 187,000 BPSD.

The Type E (or integrated) refinery has a full complement of process modules for the production of fuels, lubricants, and petrochemicals. The emissions from a Type E refinery can be estimated by:

Emissions (lb/day) = 30,114 + (86.5)(Crude Rate in 10^3 BPD)

The average Type E refinery has a crude capacity of 312,000 BPSD.

As stated before, the accuracy of emission estimates from the model is directly related to the detail and accuracy of the input data. Since the quick estimations presented in this section represent the least possible input data, it should be remembered that the confidence intervals for these estimates are quite wide (probably an order-of-magnitude or more).

7.2.2 Application of Model to Synfuel Plants

This section gives default values that can be used to obtain an estimate for the VOC emission rate from synfuel plants if all that is known is the type of synfuel plant and its coal or shale feed rate.

Three types of plants are considered:

- Coal gasification to produce SNG,
- Direct coal liquefaction, and
- Above ground oil shale retorting

The coal gasification plant used to obtain an overall VOC emission factor was the Great Plains plant described in more detail in Section 7.3.2. The plant has a coal feedrate of 26,040 tons per day, and consists of Lurgi gasifiers, gas cooling trains, shift conversion, Rectisol acid gas removal, methanation, gas compression and drying, gas liquor separation, Phenosolvan unit, sulfur recovery unit, ammonia recovery unit, by product storage tanks, auxiliary boilers, cooling tower, and flares. Overall VOC emissions from the plant were estimated at 2,250 lb/day. This is 0.084 lb VOC/ton coal.

The coal liquefaction plant used to obtain an overall VOC emission factor was the EDS plant described in more detail in Section 7.3.1. The plant has a coal feedrate of 30,000 tons per day and consists of the following modules: slurry drying, liquefactional product separation, bottoms coking, acid gas removal, light ends recovery, steam reforming/H_2 production, solvent regeneration, product storage tanks, Phenosolvan wastewater extraction, wastewater treatment, cooling towers, flares, boilers, and product loading. Overall emissions of 20,367 lb per day translate to 0.68 lb VOC per ton of coal liquefied.

The oil shale plant used to obtain an overall VOC emission factor was the Colony project described in the TOSCO II Pollution Control Technical Manual. It consists of the following modules; TOSCO II oil shale retorting, gas oil hydrogeneration, steam reforming, naphtha hydrogeneration, delayed coking, oil and gas recovery, acid gas removal, C_3/C_4 splitter, wastewater treatment, cooling towers, and boilers. Overall VOC emissions of 7,807 lb/day divided by the shale feed rate of 65,780 tons/day gives an overall emission factor of 0.12 lb VOC/ton shale.

The results of the above calculations are summarized in Table 7-1.

TABLE 7-1. OVERALL EMISSION FACTOR FOR SYNFUEL PLANTS

Plant Type	VOC Emission Factor, lb/ton
Coal Gasification to SNG	0.084
Coal Liquefaction	0.68
Oil Shale Retorting	0.12

7.3 APPLICATION OF THE MODEL TO EXAMPLE PLANTS

This subsection presents the results of the application of the VOC emission model to four example plants. The detailed calculations for these examples are found in Appendix A.

7.3.1 Exxon Donor Solvent (Liquefaction)

VOC emissions were estimated for a direct coal liquefaction plant based on Exxon Donor Solvent (EDS) technology. A commercial plant study design report produced by Exxon Research and Engineering Company under a DOE contract provided the majority of the process information used in the estimate (reference 7). The design is for a plant producing C_3 and C_4 LPG, naphtha, and low sulfur fuel oil as major products, with recovered sulfur and anhydrous ammonia as by-products. The plant is designed to liquefy 27,000 tons per day of Illinois #6 coal to produce the oil equivalent of 51,000 barrels per day of liquid products.

A simplified block diagram showing the major process modules is given in Figure 7-1. Additional modules included in the emission estimate include the following:

- Product storage tanks
- Wastewater solvent extraction
- Wastewater treatment
- Cooling towers
- Flares, and
- Auxiliary boilers

Fugitive emissions were estimated using information in the design report including numbers of each module type present, pump and compressor counts,

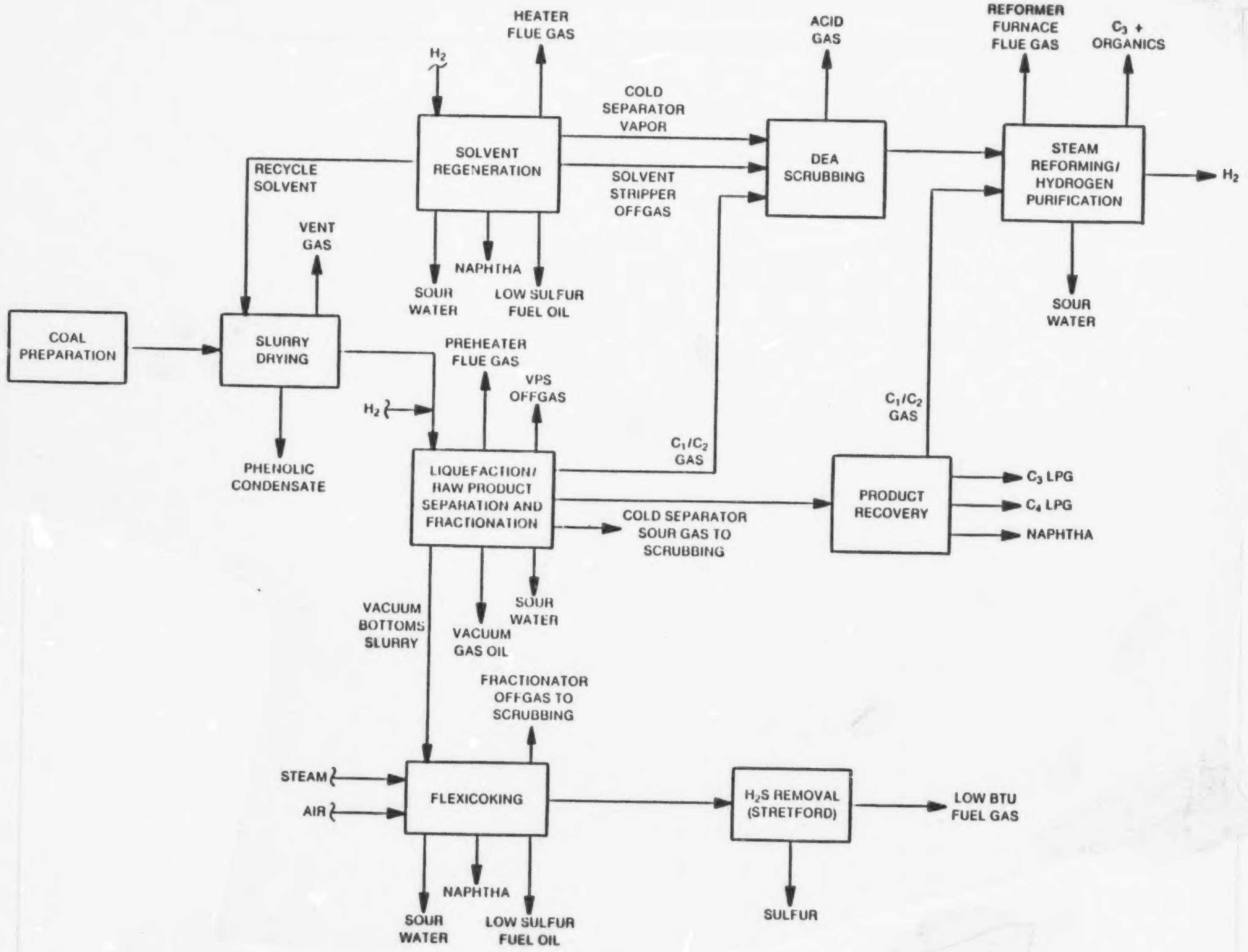

Figure 7-1. Exxon Donor Solvent Plant Simplifed Process Block Diagram

pressure vessel counts, module flow rates, wastewater and cooling water flow rate, process heater boiler heat duties, and numbers and types of storage tanks. Since complete equipment lists were not given, default values for the number of fugitive emissions sources were used. Copies of the calculation worksheets used to estimate VOC emissions for each module are given in Appendix A.

Table 7-2 summarizes the estimated emissions from each module and for the total plant. Based on the estimates, the modules producing the most VOC emissions are steam reforming/hydrogen production, liquefaction/product separation, and solvent regeneration. Emissions from steam reforming/hydrogen production were estimated using default values given for the refinery hydrogen production module, together with pump and compressor counts from the EDS Design Report. Liquefaction and initial product separation (including atmospheric and vacuum distillation) are combined in one module and therefore the use of the corresponding refinery distillation modules is not necessary. Solvent regeneration emissions were estimated based on defaults from the refinery "gas oil hydrotreating" module. Emissions for the overall plant are estimated to be about 20,400 lb/day, or about 850 lb/hour. Some control is implied in this estimate, since the slurry drying offgas and the vacuum pressure separator (VPS) vent gas, otherwise major VOC sources, are incinerated in the auxiliary boiler.

Table 7-3 gives a breakdown of VOC emissions by source type. Valves containing light liquids and hydrocarbon gases are the major emissions sources, followed closely by gas relief valves, wastewater treating and flare emissions. These five source types account for nearly 60% of the VOC emissions from the plant.

7.3.2 Great Plains Gasification Plant (Gasification)

As an example of the application of the estimating procedures to a coal gasification facility, VOC emissions were estimated for the synthetic natural

TABLE 7-2. SUMMARY OF ESTIMATED VOC EMISSIONS - EXXON DONOR SOLVENT COAL LIQUEFACTION PLANT

Module	Estimated VOC Emissions, lb/day
Slurry Drying	1,844
Liquefaction/Product Separation	2,520
Flexicoking	1,165
DEA Scrubbing	820
Light Ends Product Recovery	1,960
Steam Reforming/H_2 Purification	4,040
Solvent Regeneration	2,047
Product Storage Tanks	796
Phenol Extraction	103
Wastewater Treatment	2,002
Cooling Towers	990
Flares	1,940
Boilers	140
TOTAL PLANT	20,367

TABLE 7-3. SUMMARY OF ESTIMATED VOC EMISSIONS BY SOURCE TYPES - EXXON DONOR SOLVENT COAL LIQUEFACTION PLANT

Source Type	Estimated VOC Emissions, lb/day
Pump seals - light liquid	1,017.6
- heavy liquid	154.9
Compressor seals - hydrocarbon gas	1,166.9
- hydrogen gas	82.8
Valves - hydrocarbon gas	2,677.7
- hydrogen gas	629.6
- light liquids	2,970.5
- heavy liquids	59.5
Connections	590.4
Relief Valves - gas	2,358.4
- liquid	18.5
Open-end lines	57.9
Process drains	964.7
Sample System Pinging	191.6
Combustion Sources	138.1
Point Sources	1,428.0
Tanks - fixed roof	19.0
- floating roof	777.4
Wastewater Treating	2,002.0
Cooling Towers	993.6
Blowdown and Flares	1,944.0
Boilers	141.0

gas (SNG) plant currently under construction for Great Plains Gasification Associates in North Dakota. The plant is being built in two phases; the emissions estimates were performed based on the ultimate plant configuration and throughput. The primary source of design information was the Final Environmental Impact Statement (FEIS) submitted by DOE in 1980 (reference 38). The plant will utilize 23 operating Lurgi gasifiers to convert 26,840 tons of coal per day into SNG via catalytic methanation of the cleaned and shifted coal gas. The gasifier by product liquids (tar, tar oil, naphtha, and phenol) will be consumed onsite as boiler and superheater fuel. Figure 7-2 is a simplified block diagram of the plant.

The major process modules included in the estimate are:

- Coal gasification and gas cooling,
- Phenosolvan wastewater extraction,
- Rectisol acid gas removal,
- Wastewater treatment,
- Steam generation/super heating,
- Cooling tower,
- Flares, and
- Storage tanks

Other process modules are included in the plant design, but were not included in the estimate since their contribution to the overall VOC emissions from the plant will likely be insignificant. These include ash handling and storage shift conversion, Stretford sulfur recovery, Phosam ammonia recovery, methanation, and gas compression. The plant will produce makeup methanol for use in the Rectisol plant, but no data were found as to the size of this module, so no emissions were calculated. The methanol synthesis plant will likely be small and contribute only a small amount of emitted VOC.

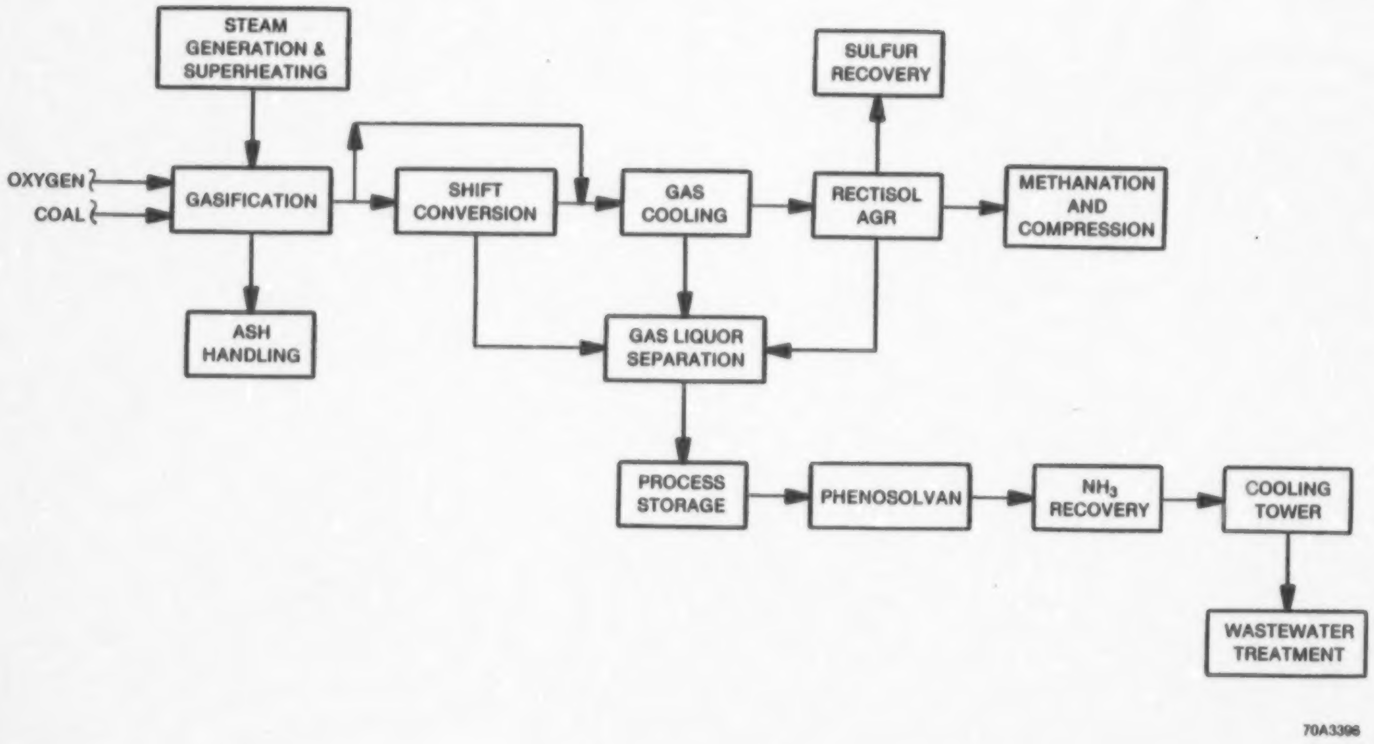

Figure 7-2. Simplified Block Diagram of the Great Plains Gasification Plant

Very little detail as to equipment counts was available, so module default values were used extensively in the estimates. Boiler fuel duties, flare rates, wastewater rates, tankage requirements, cooling water flow rates, and numbers of gasifiers, cooling trains, Rectisol and Phenosolvan trains, were available from the FEIS. Since the concentration of organics in the Lurgi product gas will be much less than corresponding refinery gas streams, modified emissions factors for the gasification/gas cooling, acid gas removal, and Phenosolvan modules were used. These factors are discussed in Section 4.4.3.

Table 7-4 summarizes the estimated VOC emissions from the Great Plains plant. The modules contributing the most VOC emissions appear to be storage tanks, wastewater treatment, steam generation/superheating, Rectisol acid gas removal, and gasification/gas cooling. The total plant emissions are approximately 2250 lb/day or 94 lb/hour. Estimated VOC emissions found in the Final Environmental Impact Statement are 140 lb/hour. The reasons for the discrepancy are not known, since no details of the calculation methodology used are given in the reference.

Table 7-5 gives a breakdown of estimated VOC emissions by source type. Most of the emissions are estimated to come from process drains, fixed roof tanks, wastewater treating, and boiler flue gas.

7.3.3 Small Existing Refinery

The VOC emission calculation model was first tested on a small refinery example. Table 7-6 lists the modules which represent the small refinery, and Figure 7-3 is a block diagram. The results of the model are summarized in Table 7-7. No detailed calculation sheets are included for this example, since the bulk of the work was done on computer.

As has been described elsewhere, the VOC emission model has multiple levels of default to allow each user to take advantage of whatever data is available. Table 7-8 presents a comparison of the model results using three different levels of default.

TABLE 7-4. SUMMARY OF ESTIMATED VOC EMISSIONS - GREAT PLAINS GASIFICATION PLANT

Module	Estimated VOC Emissions, lb/day
Gasification/Gas Cooling	317
Acid Gas Removal	342
Phenosolvan	104
Steam Generation/Superheating	330
Flares	126
Wastewater Treatment	383
Storage Tanks	502
Cooling Tower	148
TOTAL PLANT	2,252

TABLE 7-5. SUMMARY OF ESTIMATED VOC EMISSIONS BY SOURCE TYPE - GREAT PLAINS GASIFICATION PLANT

	Estimated VOC Emissions, lb/day
Pump Seals - aqueous	0.2
- hydrocarbon liquid	1.2
Compressor Seals - hydrocarbon gas	0
- hydrogen gas	10.4
Valves - hydrocarbon gas	6.9
- hydrogen gas	0
- hydrocarbon liquid	7.9
- aqueous	5.7
Connections - hydrocarbon gas	2.9
- hydrocarbon liquid	4.6
- aqueous	0.3
Relief Valves - gas	72.2
- liquid	0.1
Open-end Lines	25.1
Process Drains	542.0
Sample System Pinging	82.9
Combustion Sources	0
Point Sources	0
Tanks - fixed roof	405.0
- floating roof	98.0
Wastewater Treating	383.0
Cooling Towers	148.0
Blowdown & Flares	126.0
Boilers	329.0

TABLE 7-6.
EXAMPLE REFINERY

SMALL EXISTING REFINERY*

CRUDE CAPACITY--50,000 BPD

LIST OF MODULES:

- PROCESS MODULES
  - ATMOSPHERIC CRUDE DISTILLATION
  - VACUUM CRUDE DISTILLATION
  - NAPHTHA HYDROTREATING
  - CATALYTIC REFORMING
  - AROMATICS EXTRACTION
  - FLUID CATALYTIC CRACKING
  - LIGHT ENDS RECOVERY AND FRACTIONATION
  - OTHER MISCELLANEOUS FRACTIONATION
  - ALKYLATION
- AUXILIARY MODULES
  - BOILER
  - BLOWDOWN SYSTEM AND FLARES
  - WASTEWATER COLLECTION AND TREATING
  - STORAGE--FIXED ROOF TANKS
  - STORAGE--FLOATING ROOF TANKS
  - COOLING TOWERS
  - LOADING RACKS--TRUCKS OR RAIL CARS

*Source--DEVELOPMENT OF PETROLEUM REFINERY PLOT PLANS, EPA-450/3-78-025.

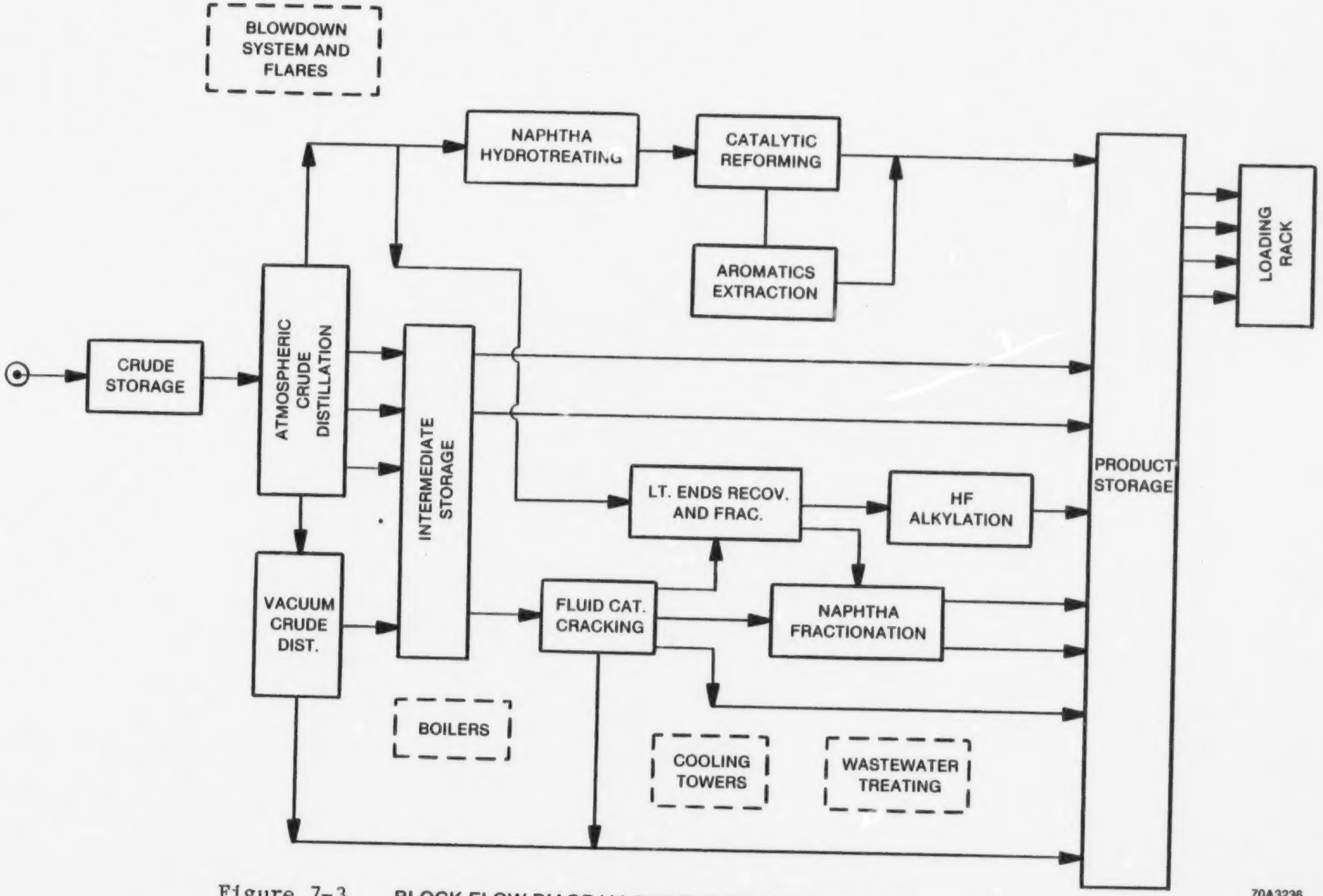

Figure 7-3. BLOCK FLOW DIAGRAM FOR THE EXAMPLE REFINERY

TABLE 7-7.

SUMMARY OF BASELINE EMISSIONS

Source Type/Service	Emissions (lb/day)	Percent of Total
Pumps/Light Liquid	522	2.5%
Pumps/Heavy Liquid	53	0.3
Compressors/Hydrocarbon Gas	238	1.1
Compressors/Hydrogen Gas	6	neg.
Valves/Hydrocarbon Gas	4938	23.7
Valves/Hydrogen Gas	142	0.7
Valves/Light Liquids	4950	23.8
Valves/Heavy Liquids	60	0.3
Connections/All	748	3.6
Relief Valves/Gas	1446	6.9
Relief Valves/Liquid	33	0.1
Open-End Lines/All	42	0.2
Process Drains/All	539	2.6
Combustion Sources	91	0.4
Other Point Sources	450	2.2
Wastewater Collection and Treating	1056	5.1
Cooling Towers	1314	6.3
Blowdown System and Flares	110	0.5
Loading Racks	308	1.5
Fixed Roof Storage	1485	7.1
Floating Roof Storage	2306	11.1
Totals	20,837 lb/day	100.0%

TABLE 7-8.

COMPARISON OF DEFAULT CASES

Source Type	BASELINE EMISSIONS Minimum Default Case (lb/day)	 Moderate Default Case (lb/day)	 Maximum Default Case (lb/day)
Process Fugitives	13,717	6911	12,857
Combustion Emissions	91	75	35
Other Point Sources	450	324	324
Wastewater Treating	1056	388	400
Cooling Towers	1314	501	501
Blowdown and Flares	110	40	40
Storage	3791	5373	1782
Loading	308	1496	1496
Totals	20,837 lb/day	15,108 lb/day	17,435 lb/day

7.3.4 Large Existing Refinery

A large existing refinery is one of the most challenging examples to which the VOC model can be applied. Such refineries have evolved slowly resulting in a large number of process and auxiliary units. The large existing refinery (∿315,000 BPSD) input data were taken from reference 12. A block flow diagram for the example refinery is given as Figure 7-4. This flow diagram has been simplifed to show only one block for each type of process unit (regardless of how many individual units it might represent), and it shows only the process modules (no auxiliary modules shown).

The detailed calculation sheets for this example are given in Appendix A-3. Table 7-9 summarizes the emissions by module, while Table 7-10 summarizes by source type. Note that control efficiencies have been added to the latter table to explore possibilities for reducing VOC emissions. The control factors given represent a fairly stringent program, including:

- quarterly LDRP on pump seals,
- enclose and vent compressor seals to the flares,
- quarterly LDRP on valves,
- enclose and vent relief valves to the flare,
- plug or cap all open end lines,
- use a closed purge on sample systems,
- vent the barometric condenser to the flare, and
- cover and vent the oil-water separator and DAF.

The user may explore any level of emission control using factors from Section 4 or other more detailed references.

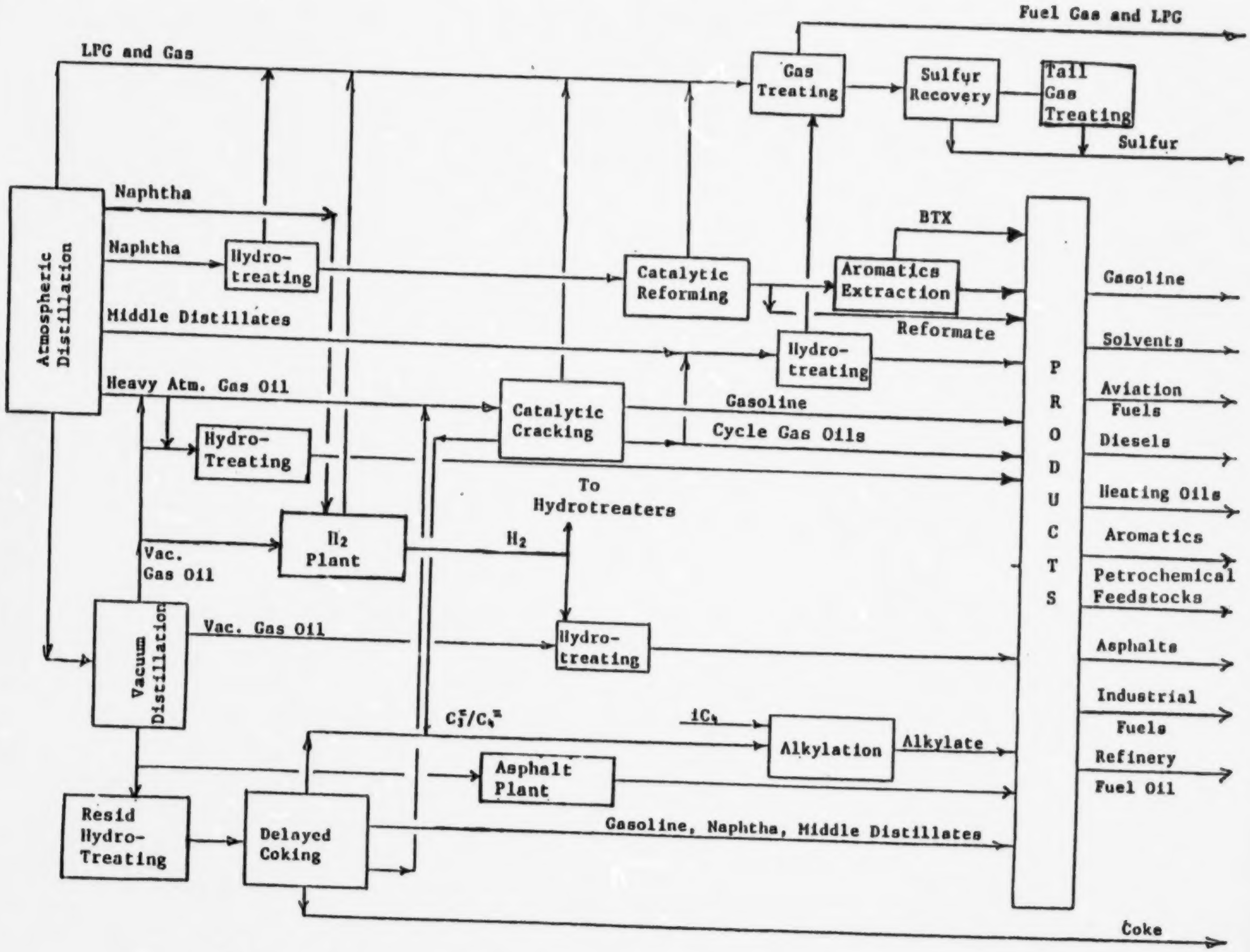

Figure 7-4. Block flow diagram of model refinery.

TABLE 7-9. SUMMARY OF EMISSIONS BY SOURCE TYPE LARGE REFINERY EXAMPLE

Source Type	Baseline Emissions (lb/day)	Control Factor (%)	Controlled Emissions (lb/day)
Pump Seals - All Services	2,745	70	824
Compressor Seals - All Services	1,216	98	24
Valves - All Services	25,707	70	7,712
Connections	2,130	None	2,130
Relief Valves - All Services	5,446	65	1,906
Open End Lines Sample Systems	1,065	100	0
Process Drains	2,045	None	2,045
Heaters and Boilers	382	None	382
Point Sources	972	98	19
Wastewater Treating	2,514	0.84	397
Cooling Towers	3	None	3
Blowdown System and Flares	252	None	252
Product Loading Operations	5,373	None	5,373
Storage Tanks -			
Fixed Roof	2,664	None	2,664
Floating Roof	9,462	None	9,462
TOTALS	61,976 lb/day	Avg. 53%	33,193 lb/day

TABLE 7-10. SUMMARY OF EMISSIONS BY MODULE
LARGE REFINERY EXAMPLE

Module Name	Emissions (lb/day)
Distillation and Light Ends Recovery	4,474
Middle Distillate Hydrotreating	657
Catalytic Reformer	785
Naphtha Hydrotreater	1,409
Middle Distillate Hydrotreater	1,426
Hydrogen Production	2,064
Hydrogen Production	508
Naphtha Hydrotreater	1,409
Gas Oil Hydrotreater	924
Misc. Fractionation	294
Misc. Fractionation	402
Atmospheric Crude Distillation	1,171
Vacuum Crude Distillation	1,340
Catalytic Reformer	824
Resid Hydrodesulfurizer	371
Hydrogen Production	2,064
Alkylation	1,780
Polymerization	1,023
Misc. Fractionation	744
Gas Oil Hydrotreater	506
Catalytic Reformed	1,490
Aromatics Extraction	1,548
Catalytic Cracking	2,569
Non-Volatile Petrochemical Unit	260
Delayed Coker	1,348
Asphalt Production	78
Non-Volatile Lube Oil Process	207
Gasoline Treating	373
Atmospheric Crude Distillation	1,171
Vacuum Crude Distillation	368
Atmospheric Crude Distillation	1,148
Vacuum Crude Distillation	441
Atmospheric Crude Distillation	555
Atmospheric Crude Distillation	555
Misc. Fractionation	3,150
Light Ends Recovery and Distillation	2,287
Boilers	25
Wastewater Treating	2,514
Cooling Towers	3
Blowdown System and Flares	252
Product Loading Operations	5,373
Storage Tanks	12,086
TOTAL EMISSIONS	61,976 lb/day

SECTION 8

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APPENDIX A

DETAILED RESULTS OF CALCULATIONS FOR THREE EXAMPLE CASES

CASE 1

EXXON DONOR SOLVENT (LIQUEFACTION) PLANT

EMISSION CALCULATION SHEET

MODULE NAME SLURRY DRYING

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	16 (see default #1)	=	96.0
Pump Seals	Heavy Liquid (HL)	1.1	×	16 (see default #1)	=	17.6
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	8 × 0.04* (see default #2)	=	10.9
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	32 (see default #3)	=	128.0
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	320 (see default #3)	=	185.6
Valves	Heavy Liquids (HL)	0.012	×	320 (see default #3)	=	3.8
Connections	All	0.013	×	3024 (see default #4)	=	39.3
Relief Valves	Gas (G)	8.6	×	16 (see default #5)	=	137.6
Relief Valves	Liquid (L)	0.37	×	0 (see default #5)	=	0
Open End Lines	All	0.12	×	36 (see default #6)	=	4.3
Process Drains	All	1.7	×	52 (see default #7)	=	88.4
Sample System Purging	All	0.79	×	18 (see default #7C) =	=	14.2

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* fraction hydrocarbon

SLURRY DRYING

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	(see default #8)	=			0
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			0
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
Dryer vent gas	10.8×10^6 (see default #9)	×	40,000 (see default #9)	×	98 (see default #9)	× 2.64×10^{-9} ×0.01* =	1,118
		×		×		× 2.64×10^{-9} =	
		×		×		× 2.64×10^{-9} =	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	
		×		=	
		×		=	

*Routed to boiler - assume 99% destruction

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=	—	

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EMISSION CALCULATION SHEET

MODULE NAME LIQUEFACTION / PRODUCT SEPARATION

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	40 (see default #1)	=	240
Pump Seals	Heavy Liquid (HL)	1.1	×	56 (see default #1)	=	61.6
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	4 (see default #2)	=	10.4
Valves	Hydrocarbon Gas (HCG)	1.4	×	200 (see default #3)	=	280
Valves	Hydrogen Gas (HYD)	0.43	×	200 (see default #3)	=	86
Valves	Light Liquids (LL)	0.58	×	664 (see default #3)	=	385
Valves	Heavy Liquids (HL)	0.012	×	948 (see default #3)	=	11.4
Connections	All	0.013	×	9,072 (see default #4)	=	117.9
Relief Valves	Gas (G)	8.6	×	68 (see default #5)	=	585
Relief Valves	Liquid (L)	0.37	×	16 (see default #5)	=	5.9
Open End Lines	All	0.12	×	104 (see default #6)	=	12.5
Process Drains	All	1.7	×	148 (see default #7)	=	252
Sample System Purging	All	0.79	×	52 (see default #7C) =	=	41

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LIQ/PROD SEP

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	42,854 (see default #8)		=	124
	Or	3.0 lb/10^6 scf	×		(see default #8) 10^6 scf/day	=	
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)		=	
	Or	1.0 lb/10^3 gal	×		(see default #8) 10^3 gal/day	=	
Coal		1.0 lb/ton	×		(see default #8) tons/day	=	

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
VRS vent gas	256,000 (see default #9)	×	10^6 (see default #9)	×	46 (see default #9)	$\times 2.64 \times 10^{-9}$ $\times 0.01$ * =	310
		×		×		$\times 2.64 \times 10^{-9}$ =	
		×		×		$\times 2.64 \times 10^{-9}$ =	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	
		×		=	
		×		=	

* Routed to boiler - assume 99% destruction

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=	–	

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EMISSION CALCULATION SHEET

MODULE NAME FLEXICOKING (FLUID BED COKING)

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	12.6 (see default #1)	=	75.6
Pump Seals	Heavy Liquid (HL)	1.1	×	37.8 (see default #1)	=	41.6
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	6 (see default #2)	=	204
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	116 (see default #3)	=	162.4
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	261 (see default #3)	=	151.4
Valves	Heavy Liquids (HL)	0.012	×	782 (see default #3)	=	9.4
Connections	All	0.013	×	3941 (see default #4)	=	51.2
Relief Valves	Gas (G)	8.6	×	27 (see default #5)	=	232.2
Relief Valves	Liquid (L)	0.37	×	3 (see default #5)	=	1.1
Open End Lines	All	0.12	×	86 (see default #6)	=	10.3
Process Drains	All	1.7	×	111 (see default #7)	=	188.7
Sample System Purging	All	0.79	×	43 (see default #7C) =	=	34.0

- FLEXICOKING -

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	(see default #8)	=			0
	Or	3.0 lb/10^6 scf	×			(see default #8)	10^6 scf/day =	
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			0
	Or	1.0 lb/10^3 gal	×			(see default #8)	10^3 gal/day =	
Coal		1.0 lb/ton	×			(see default #8)	tons/day =	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	0
		×		×		× 2.64×10^{-9} =	
		×		×		× 2.64×10^{-9} =	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	
		×		=	
		×		=	

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=	—	

EMISSION CALCULATION SHEET

MODULE NAME Acid Gas Removal (DEA Scrubbing)

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	25 (see default #1)	=	150
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	115 (see default #3)	=	161
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	460 (see default #3)	=	266.8
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	1610 (see default #4)	=	20.9
Relief Valves	Gas (G)	8.6	×	16 (see default #5)	=	137.6
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	0.7
Open End Lines	All	0.12	×	28 (see default #6)	=	3.4
Process Drains	All	1.7	×	40 (see default #7)	=	68
Sample System Purging	All	0.79	×	14 (see default #7C) =	=	11

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EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	(see default #8)	=			0
	Or	3.0 lb/10^6 scf	×			(see default #8)	10^6 scf/day =	
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			0
	Or	1.0 lb/10^3 gal	×			(see default #8)	10^3 gal/day =	
Coal		1.0 lb/ton	×			(see default #8)	tons/day =	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	0
		×		×		× 2.64×10^{-9} =	
		×		×		× 2.64×10^{-9} =	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	
		×		=	
		×		=	

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		

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EMISSION CALCULATION SHEET

MODULE NAME Light Ends Recovery

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	25 (see default #1)	=	150
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	468 (see default #3)	=	655.2
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	1482 (see default #3)	=	859.6
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	6435 (see default #4)	=	83.7
Relief Valves	Gas (G)	8.6	×	14 (see default #5)	=	120.4
Relief Valves	Liquid (L)	0.37	×	14 (see default #5)	=	5.2
Open End Lines	All	0.12	×	30 (see default #6)	=	3.6
Process Drains	All	1.7	×	44 (see default #7)	=	74.8
Sample System Purging	All	0.79	×	15 (see default #7C) =	=	11.9

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Lt Ends Rec.

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	(see default #8)	=			0
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			0
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	0
		×		×		× 2.64×10^{-9} =	
		×		×		× 2.64×10^{-9} =	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	
		×		=	
		×		=	

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=	—	

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EMISSION CALCULATION SHEET

MODULE NAME Hydrogen Production

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	45 (see default #1)	=	270
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	28 (see default #2)	=	952
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	24 (see default #2)	=	62
Valves	Hydrocarbon Gas (HCG)	1.4	×	280 (see default #3)	=	392
Valves	Hydrogen Gas (HYD)	0.43	×	316 (see default #3)	=	136
Valves	Light Liquids (LL)	0.58	×	1708 (see default #3)	=	991
Valves	Heavy Liquids (HL)	0.012	×	1708 (see default #3)	=	20
Connections	All	0.013	×	13380 (see default #4)	=	174
Relief Valves	Gas (G)	8.6	×	101 (see default #5)	=	869
Relief Valves	Liquid (L)	0.37	×	11 (see default #5)	=	4
Open End Lines	All	0.12	×	100 (see default #6)	=	12
Process Drains	All	1.7	×	68 (see default #7)	=	116
Sample System Purging	All	0.79	×	50 (see default #7C) =	=	40

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EMISSION CALCULATION SHEET

MODULE NAME Hydrogen Production

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	45 (see default #1)	=	270
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	28 (see default #2)	=	952
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	24 (see default #2)	=	62
Valves	Hydrocarbon Gas (HCG)	1.4	×	280 (see default #3)	=	392
Valves	Hydrogen Gas (HYD)	0.43	×	316 (see default #3)	=	136
Valves	Light Liquids (LL)	0.58	×	1708 (see default #3)	=	991
Valves	Heavy Liquids (HL)	0.012	×	1708 (see default #3)	=	20
Connections	All	0.013	×	13380 (see default #4)	=	174
Relief Valves	Gas (G)	8.6	×	101 (see default #5)	=	869
Relief Valves	Liquid (L)	0.37	×	11 (see default #5)	=	4
Open End Lines	All	0.12	×	100 (see default #6)	=	12
Process Drains	All	1.7	×	68 (see default #7)	=	116
Sample System Purging	All	0.79	×	50 (see default #7C) =	=	40

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H_2 Prod.

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	72 (see default #8)	=			0.2
	Or	3.0 lb/10^6 scf	×			(see default #8)	10^3 scf/day =	
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			0
	Or	1.0 lb/10^3 gal	×			(see default #8)	10^3 gal/day =	
Coal		1.0 lb/ton	×			(see default #8)	tons/day =	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	0
		×		×		× 2.64×10^{-9} =	
		×		×		× 2.64×10^{-9} =	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	
		×		=	
		×		=	

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=	–	

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EMISSION CALCULATION SHEET

MODULE NAME Solvent Hydrogenation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	6 (see default #1)	=	36
Pump Seals	Heavy Liquid (HL)	1.1	×	31 (see default #1)	=	34.1
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	4 (see default #2)	=	10.4
Valves	Hydrocarbon Gas (HCG)	1.4	×	642 (see default #3)	=	898.8
Valves	Hydrogen Gas (HYD)	0.43	×	948 (see default #3)	=	407.6
Valves	Light Liquids (LL)	0.58	×	226 (see default #3)	=	131.1
Valves	Heavy Liquids (HL)	0.012	×	1242 (see default #3)	=	14.9
Connections	All	0.013	×	7951 (see default #4)	=	103.4
Relief Valves	Gas (G)	8.6	×	32 (see default #5)	=	275.2
Relief Valves	Liquid (L)	0.37	×	4 (see default #5)	=	1.5
Open End Lines	All	0.12	×	67 (see default #6)	=	8.0
Process Drains	All	1.7	×	56 (see default #7)	=	95.2
Sample System Purging	All	0.79	×	34 (see default #7C) =	=	26.9

SOLVENT HYDROG.

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption			
Gas	Either	0.0029 lb/10^6 Btu	×	4,795.2 (see default #8)	=				13.9
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day	=	
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=				0
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day	=	
Coal		1.0 lb/ton		×		(see default #8)	tons/day	=	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)			
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9}	=	0
		×		×		× 2.64×10^{-9}	=	
		×		×		× 2.64×10^{-9}	=	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	
		×		=	
		×		=	

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=	—	

FIXED ROOF TANK EMISSION CALCULATION SHEET
(See Default 1)

VACUUM GAS OIL

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68} (D)^{1.73}\ (H)^{0.51}\ (\Delta T)^{0.5}\ (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \overset{296.4}{(M)}\ \left(\frac{0.00019}{14.7 - \underset{0.00019}{}}\right)^{0.68} \underset{80}{(\quad)}^{1.73}\ \underset{29.3}{(\quad)}^{0.51}\ \underset{21.5}{(\quad)}^{0.5}\ \underset{1.0}{(\quad)}\underset{1.0}{(\quad)}\underset{1.0}{(\quad)}$$

LB = 1.6 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})\overset{296.4}{(\quad)}\overset{0.00019}{(\quad)}\overset{1.0}{(\quad)}\overset{1.0}{(\quad)}$$

LW = 0.0014 lb/10³ gal.

where: LW = Fixed roof working loss (lb/10^3 gal. throughput)
M = see above
P = see above
KN = Turnover factor (dimensionless), see Default 2i.
KC = Crude oil factor (dimensionless), see Default 2j.

Working Loss Per Day

$$LWPD = (LW)(TP) = \overset{0.0014}{(\ )}\ \overset{280.6}{(\ )} = \underline{\quad 0.38 \quad} \text{ lb/day}$$

where LWPD = Working loss per day (lb/day)
LW = see above
TP = Average daily throughput (10^3 gal./day), see Default 2k.

Total Emissions Per Tank

$$TEPT = (LB) + (LWPD) = \overset{1.6}{(\ \ )} + \overset{0.38}{(\ \ )} = \underline{\quad 1.98 \quad} \text{ lb/day}$$

where TEPT = Total emissions per tank (lb/day)

Total Emissions for a Group of Identical Tanks

$$TEG = (TEPT)(N) = \overset{1.98}{(\ \ )}\ \overset{2}{(\ \ )} = \underline{\quad 3.96 \quad} \text{ lb/day}$$

where TEG = Total emissions for a group of identical tanks (lb/day)
TEPT = see above
N = Number of identical tanks in the facility understudy, see Default 1b.

FIXED ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

Flexicoking Products

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68} (D)^{1.73}\ (H)^{0.51}\ (\Delta T)^{0.5}\ (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \overset{302.7}{(M)}\ \left(\frac{.00019}{14.7 - .00019}\right)^{0.68} \underset{150}{(\quad)}^{1.73}\ \underset{30.5}{(\ )}^{0.51}\ \underset{21.5}{(\quad)}^{0.5}\ \underset{1.0}{(\quad)}\underset{1.0}{(\ )}\underset{1.0}{(\quad)}$$

LB = 4.9 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})\overset{302.7}{(\quad)}\overset{.00019}{(\quad)}\overset{1.0}{(\quad)}\overset{1.0}{(\quad)}$$

LW = 0.0014 $lb/10^3$ gal.

where: LW = Fixed roof working loss (lb/10^3 gal. throughput)
M = see above
P = see above
KN = Turnover factor (dimensionless), see Default 2i.
KC = Crude oil factor (dimensionless), see Default 2j.

Working Loss Per Day

$LWPD = (LW)(TP) = \overset{0.0014}{(\ )}\ \overset{987.3}{(\ )} = \underline{\quad 1.4 \quad}$ lb/day

where LWPD = Working loss per day (lb/day)
LW = see above
TP = Average daily throughput (10^3 gal./day), see Default 2k.

Total Emissions Per Tank

$TEPT = (LB) + (LWPD) = \overset{4.9}{(\quad)} + \overset{1.4}{(\quad)} = \underline{\quad 6.3 \quad}$ lb/day

where TEPT = Total emissions per tank (lb/day)

Total Emissions for a Group of Identical Tanks

$TEG = (TEPT)(N) = \overset{6.3}{(\quad)}\ \overset{2}{(\quad)} = \underline{\quad 12.6 \quad}$ lb/day

where TEG = Total emissions for a group of identical tanks (lb/day)
TEPT = see above
N = Number of identical tanks in the facility understudy, see Default 1b.

FIXED ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

HOT RERUN SLOPS

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68} (D)^{1.73}\ (H)^{0.51}\ (\Delta T)^{0.5}\ (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \overset{158.5}{(M)}\ \left(\frac{.00019}{14.7 - .00019}\right)^{0.68} \underset{138}{(\ \ )}^{1.73}\ \underset{30.3}{(\ )}^{0.51}\ \underset{21.5}{(\ \ )}^{0.5}\ \underset{1.0}{(\ \ )}\underset{1.0}{(\ )}\underset{1.0}{(\ \ )}$$

LB = 2.2 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})\overset{158.5}{(\ \ )}\overset{.00019}{(\ \ )}(1.0)(1.0)$$

LW = 0.00072 lb/10^3 gal.

where: LW = Fixed roof working loss (lb/10^3 gal. throughput)
M = see above
P = see above
KN = Turnover factor (dimensionless), see Default 2i.
KC = Crude oil factor (dimensionless), see Default 2j.

Working Loss Per Day

$\text{LWPD} = (\text{LW})(\text{TP}) = \overset{0.00072}{(\ )}\ \overset{417.8}{(\ )} = \underline{\quad 0.3 \quad}$ lb/day

where LWPD = Working loss per day (lb/day)
LW = see above
TP = Average daily throughput (10^3 gal./day), see Default 2k.

Total Emissions Per Tank

$\text{TEPT} = (\text{LB}) + (\text{LWPD}) = \overset{2.2}{(\ )} + \overset{0.3}{(\ )} = \underline{\quad 2.5 \quad}$ lb/day

where TEPT = Total emissions per tank (lb/day)

Total Emissions for a Group of Identical Tanks

$\text{TEG} = (\text{TEPT})(\text{N}) = \overset{2.5}{(\ )}\ \overset{1}{(\ )} = \underline{\quad 2.5 \quad}$ lb/day

where TEG = Total emissions for a group of identical tanks (lb/day)
TEPT = see above
N = Number of identical tanks in the facility understudy, see Default 1b.

FLOATING ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

– Naphtha –

Standing Storage Loss

$$LS = (9.21 \times 10^{-3})(M)\left(\frac{P}{14.7 - P}\right)^{0.7} (D)^{1.5} (VW)^{0.7} (KT)(KS)(KP)(KC)$$

$$LS = (9.21 \times 10^{-3})\overset{90.4}{(\ )}\left(\frac{1.5}{14.7 - 1.5}\right)^{0.7} \underset{182}{(\ )}^{1.5} \underset{10.2}{(\ )}^{0.7} \underset{0.11}{(\ )}\underset{1.0}{(\ )}\underset{0.9}{(\ )}\underset{1.0}{(\ )}$$

LS = 203.6 lb/day

where: LS = Floating roof standing storage loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 3a.

VW = Average wind velocity (mi/hr), see Default 3b.

KT = Tank type factor (dimensionless), see Default 3c.

KS = Seal factor (dimensionless), see Default 3d.

KP = Paint factor (dimensionless), see Default 3e.

KC = Crude oil factor (dimensionless), see Default 3f.

Withdrawal Loss

$$LWD = \frac{(22.4)(d)(CF)}{(D)} = \frac{(22.4)\overset{6.4}{(\ )}\overset{0.02}{(\ )}}{\underset{182}{(\ )}}$$

LWD = 0.0158 lb/10^3 gal. throughput

where: LWD = Floating roof withdrawal loss (lb/10^3 gal throughput)

d = Density of stored liquid at bulk liquid conditions (lb/gal), see Default 3g.

CF = Tank construction factor (dimensionless), see Default 3h.

D = Tank diameter (ft), see Default 1c.

Withdrawal Loss Per Day

LWDPD = (LWD)(TP) = (0.0158)(587.1) = 9.2 lb/day

where: LWDPD = Withdrawal loss per day (lb/day)

TP = Average daily throughput (10^3 gal/day), see Default 2k.

Total Emissions Per Tank

TEPT = (LS) +)LWDPD) = (203.6) + (9.2) = 212.8 lb/day

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(No. of Tanks) = (212.8)(2) = 425.6 lb/day

FLOATING ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

-Fuel Oil-

Standing Storage Loss

$$LS = (9.21 \times 10^{-3})(M)\left(\frac{P}{14.7 - P}\right)^{0.7}(D)^{1.5}(VW)^{0.7}(KT)(KS)(KP)(KC)$$

$$LS = (9.21 \times 10^{-3})\overset{302.7}{(\ )}\left(\frac{.00004}{14.7 - \underset{.00004}{\ }}\right)^{0.7}\underset{172}{(\ )}^{1.5}\underset{10.2}{(\ )}^{0.7}\underset{0.11}{(\ )}\underset{1.0}{(\ )}\underset{0.9}{(\ )}\underset{1.0}{(\ )}$$

LS = 0.4 lb/day

where: LS = Floating roof standing storage loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 3a.

VW = Average wind velocity (mi/hr), see Default 3b.

KT = Tank type factor (dimensionless), see Default 3c.

KS = Seal factor (dimensionless), see Default 3d.

KP = Paint factor (dimensionless), see Default 3e.

KC = Crude oil factor (dimensionless), see Default 3f.

Withdrawal Loss

$$LWD = \frac{(22.4)(d)(CF)}{(D)} = \frac{(22.4)\overset{8.8}{(\ )}\overset{0.02}{(\ )}}{\underset{172}{(\ )}}$$

LWD = 0.0229 lb/10^3 gal. throughput

where: LWD = Floating roof withdrawal loss (lb/10^3 gal throughput)

d = Density of stored liquid at bulk liquid conditions (lb/gal), see Default 3g.

CF = Tank construction factor (dimensionless), see Default 3h.

D = Tank diameter (ft), see Default 1c.

Withdrawal Loss Per Day

LWDPD = (LWD)(TP) = (0.0229)(208.4) = 4.8 lb/day

where: LWDPD = Withdrawal loss per day (lb/day)

TP = Average daily throughput (10^3 gal/day), see Default 2k.

Total Emissions Per Tank

TEPT = (LS) + (LWDPD) = (0.4) + (4.8) = 5.2 lb/day

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(No. of Tanks) = (5.2)(2) = 10.4 lb/day

FLOATING ROOF TANK EMISSION CALCULATION SHEET
(See Default 1)

- Crude Phenol -

Standing Storage Loss

$$LS = (9.21 \times 10^{-3})(M)\left(\frac{P}{14.7 - P}\right)^{0.7} (D)^{1.5} (VW)^{0.7} (KT)(KS)(KP)(KC)$$

$$LS = (9.21 \times 10^{-3})\overset{190}{(\ )}\left(\frac{\overset{.02}{\ }}{14.7 - .02}\right)^{0.7} \underset{32}{(\ )}^{1.5} \underset{10.2}{(\ )}^{0.7} \underset{0.11}{(\ )}\underset{1.0}{(\ )}\underset{0.9}{(\ )}\underset{1.0}{(\ )}$$

LS = 1.6 lb/day

where: LS = Floating roof standing storage loss (lb/day)
M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.
P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.
D = Tank diameter (ft.), see Default 3a.
VW = Average wind velocity (mi/hr), see Default 3b.
KT = Tank type factor (dimensionless), see Default 3c.
KS = Seal factor (dimensionless), see Default 3d.
KP = Paint factor (dimensionless), see Default 3e.
KC = Crude oil factor (dimensionless), see Default 3f.

Withdrawal Loss

$$LWD = \frac{(22.4)(d)(CF)}{(D)} = \frac{(22.4)\overset{7.9}{(\ )}\overset{.02}{(\ )}}{\underset{32}{(\ )}}$$

LWD = 0.11 $lb/10^3$ gal. throughput

where: LWD = Floating roof withdrawal loss ($lb/10^3$ gal throughput)
d = Density of stored liquid at bulk liquid conditions (lb/gal), see Default 3g.
CF = Tank construction factor (dimensionless), see Default 3h.
D = Tank diameter (ft), see Default 1c.

FLOATING ROOF TANK EMISSION CALCULATION SHEET
(See Default 1)

-Excess Solvent-

Standing Storage Loss

$$LS = (9.21 \times 10^{-3})(M)\left(\frac{P}{14.7 - P}\right)^{0.7} (D)^{1.5} (VW)^{0.7} (KT)(KS)(KP)(KC)$$

$$LS = (9.21 \times 10^{-3})\overset{158}{(\ )}\left(\frac{.02}{14.7 - .02}\right)^{0.7} \underset{149}{(\ )}^{1.5} \underset{10.2}{(\ )}^{0.7} \underset{0.11}{(\ )}\underset{1.0}{(\ )}\underset{0.9}{(\ )}\underset{1.0}{(\ )}$$

LS = 13.1 lb/day

where: LS = Floating roof standing storage loss (lb/day)
M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.
P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.
D = Tank diameter (ft.), see Default 3a.
VW = Average wind velocity (mi/hr), see Default 3b.
KT = Tank type factor (dimensionless), see Default 3c.
KS = Seal factor (dimensionless), see Default 3d.
KP = Paint factor (dimensionless), see Default 3e.
KC = Crude oil factor (dimensionless), see Default 3f.

Withdrawal Loss

$$LWD = \frac{(22.4)(d)(CF)}{(D)} = \frac{(22.4)\overset{8.2}{(\ )}\overset{.02}{(\ )}}{\underset{149}{(\ )}}$$

LWD = 0.025 $lb/10^3$ gal. throughput

where: LWD = Floating roof withdrawal loss ($lb/10^3$ gal throughput)
d = Density of stored liquid at bulk liquid conditions (lb/gal), see Default 3g.
CF = Tank construction factor (dimensionless), see Default 3h.
D = Tank diameter (ft), see Default 1c.

Withdrawal Loss Per Day

$$\text{LWDPD} = (\text{LWD})(\text{TP}) = (\overset{0.025}{\quad})(\overset{1.0}{\quad}) = \underline{\;0.025\;}\ \text{lb/day}$$

where: LWDPD = Withdrawal loss per day (lb/day)

TP = Average daily throughput (10^3 gal/day), see Default 2k.

Total Emissions Per Tank

$$\text{TEPT} = (\text{LS}) + (\text{LWDPD}) = (\overset{13.1}{\quad}) + (\overset{.025}{\quad}) = \underline{\;13.1\;}\ \text{lb/day}$$

Total Emissions for a Group of Identical Tanks

$$\text{TEG} = (\text{TEPT})(\text{No. of Tanks}) = (\overset{13.1}{\quad})(\overset{2}{\quad}) = \underline{\;26.2\;}\ \text{lb/day}$$

FLOATING ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

-Spent Solvent-

Standing Storage Loss

$$LS = (9.21 \times 10^{-3})(M)\left(\frac{P}{14.7 - P}\right)^{0.7} (D)^{1.5} (VW)^{0.7} (KT)(KS)(KP)(KC)$$

$$LS = (9.21 \times 10^{-3})(169)\left(\frac{0.02}{14.7 - .02}\right)^{0.7} (248)^{1.5} (10.2)^{0.7} (0.11)(1.0)(0.9)(1.0)$$

LS = 23.5 lb/day

where: LS = Floating roof standing storage loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 3a.

VW = Average wind velocity (mi/hr), see Default 3b.

KT = Tank type factor (dimensionless), see Default 3c.

KS = Seal factor (dimensionless), see Default 3d.

KP = Paint factor (dimensionless), see Default 3e.

KC = Crude oil factor (dimensionless), see Default 3f.

Withdrawal Loss

$$LWD = \frac{(22.4)(d)(CF)}{(D)} = \frac{(22.4)(8.2)(0.02)}{(248)}$$

LWD = 0.0148 lb/10^3 gal. throughput

where: LWD = Floating roof withdrawal loss (lb/10^3 gal throughput)

d = Density of stored liquid at bulk liquid conditions (lb/gal), see Default 3g.

CF = Tank construction factor (dimensionless), see Default 3h.

D = Tank diameter (ft), see Default 1c.

Withdrawal Loss Per Day

LWDPD = (LWD)(TP) = (0.0148)(8279) = 122.6 lb/day

where: LWDPD = Withdrawal loss per day (lb/day)

TP = Average daily throughput (10^3 gal/day), see Default 2k.

Total Emissions Per Tank

TEPT = (LS) + (LWDPD) = (23.5) + (122.6) = 146.1 lb/day

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(No. of Tanks) = (146.1)(1) = 146.1 lb/day

FLOATING ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

– Recycle Solvent –

Standing Storage Loss

$$LS = (9.21 \times 10^{-3})(M)\left(\frac{P}{14.7 - P}\right)^{0.7} (D)^{1.5} (VW)^{0.7} (KT)(KS)(KP)(KC)$$

$$LS = (9.21 \times 10^{-3})(\overset{158}{\quad})\left(\frac{.02}{14.7 - .02}\right)^{0.7} (\underset{234}{\quad})^{1.5} (\underset{10.2}{\quad})^{0.7} (\underset{0.11}{\quad})(\underset{1.0}{\quad})(\underset{0.9}{\quad})(\underset{1.0}{\quad})$$

LS = 20.7 lb/day

where: LS = Floating roof standing storage loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 3a.

VW = Average wind velocity (mi/hr), see Default 3b.

KT = Tank type factor (dimensionless), see Default 3c.

KS = Seal factor (dimensionless), see Default 3d.

KP = Paint factor (dimensionless), see Default 3e.

KC = Crude oil factor (dimensionless), see Default 3f.

Withdrawal Loss

$$LWD = \frac{(22.4)(d)(CF)}{(D)} = \frac{(22.4)(\overset{8.2}{\quad})(\overset{0.02}{\quad})}{(\underset{234}{\quad})}$$

LWD = 0.0157 lb/10^3 gal. throughput

where: LWD = Floating roof withdrawal loss (lb/10^3 gal throughput)

d = Density of stored liquid at bulk liquid conditions (lb/gal), see Default 3g.

CF = Tank construction factor (dimensionless), see Default 3h.

D = Tank diameter (ft), see Default 1c.

Withdrawal Loss Per Day

LWDPD = (LWD)(TP) = (0.0157)(7316) = 114.9 lb/day

where: LWDPD = Withdrawal loss per day (lb/day)
TP = Average daily throughput (10^3 gal/day), see Default 2k.

Total Emissions Per Tank

TEPT = (LS) + (LWDPD) = (20.7) + (114.9) = 135.6 lb/day

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(No. of Tanks) = (135.6)(1) = 135.6 lb/day

FLOATING ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

- Cold Rerun Slops -

Standing Storage Loss

$$LS = (9.21 \times 10^{-3})(M)\left(\frac{P}{14.7 - P}\right)^{0.7} (D)^{1.5} (VW)^{0.7} (KT)(KS)(KP)(KC)$$

$$LS = (9.21 \times 10^{-3})(158)\left(\frac{.02}{14.7 - .02}\right)^{0.7} (190)^{1.5} (10.2)^{0.7} (0.11)(1.0)(0.9)(1.0)$$

LS = 16.8 lb/day

where: LS = Floating roof standing storage loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 3a.

VW = Average wind velocity (mi/hr), see Default 3b.

KT = Tank type factor (dimensionless), see Default 3c.

KS = Seal factor (dimensionless), see Default 3d.

KP = Paint factor (dimensionless), see Default 3e.

KC = Crude oil factor (dimensionless), see Default 3f.

Withdrawal Loss

$$LWD = \frac{(22.4)(d)(CF)}{(D)} = \frac{(22.4)(8.2)(0.02)}{(190)}$$

LWD = 0.0193 $lb/10^3$ gal. throughput

where: LWD = Floating roof withdrawal loss ($lb/10^3$ gal throughput)

d = Density of stored liquid at bulk liquid conditions (lb/gal), see Default 3g.

CF = Tank construction factor (dimensionless), see Default 3h.

D = Tank diameter (ft), see Default 1c.

Withdrawal Loss Per Day

LWDPD = (LWD)(TP) = (0.0193)(396) = 7.7 lb/day

where: LWDPD = Withdrawal loss per day (lb/day)
TP = Average daily throughput (10^3 gal/day), see Default 2k.

Total Emissions Per Tank

TEPT = (LS) + (LWDPD) = (16.8) + (7.7) = 24.5 lb/day

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(No. of Tanks) = (24.5)(1) = 24.5 lb/day

EMISSION CALCULATION SHEET FOR MODULES SPECIFIC TO SYNFUELS PLANTS

MODULE NAME Wastewater Solvent Extraction

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Aqueous (A)	0.0026	×	14 (see default #1)	=	0.04
Pump Seals	Hydrocarbon Liquid (HL)	0.011	×	16 (see default #1)	=	0.18
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	0.0042	×	74 (see default #3)	=	0.31
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Hydrocarbon Liquids (HL)	0.0057	×	224 (see default #3)	=	1.28
Valves	Aqueous (A)	0.0026	×	418 (see default #3)	=	1.09
Connections	Hydrocarbon Gas (HCG)	0.0005	×	266 (see default #4)	=	1.09
Connections	Hydrocarbon Liquid (HL)	0.0011	×	988 (see default #4)	=	0.13
Connections	Aqueous (A)	0.00007	×	1832 (see default #4)	=	0.13
Relief Valves	Gas (G)	0.34	×	4 (see default #5)	=	1.36
Relief Valves	Liquid (L)	0.0037	×	28 (see default #5)	=	0.10
Open End Lines	All	0.12	×	32 (see default #6)	=	3.84
Process Drains	All	1.7	×	48 (see default #7)	=	81.6
Sample System Purging	All	0.79	×	16 (see default #7c)	=	12.6

WW Solv. Ext.

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	(see default #8)	=			0
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			0
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	0
		×		×		× 2.64×10^{-9} =	
		×		×		× 2.64×10^{-9} =	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	
		×		=	
		×		=	

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=	–	

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WASTEWATER TREATING

Oil-Water Separator

Emissions (lb/day)

4260 x 0.38 = 1,619

Wastewater Flow Rate in 10^3 gal/day (See Default No. 1) x Emission Factor (See Default No. 2) =

Dissolved Air Flotation Units

4260 x 0.09 lb/10^3 gal. WW = 383

Wastewater Flow Rate in 10^3 gal/day (See Default No. 3)

Total Wastewater Emissions (Sum of the emissions from the OWS and DAF) = 2,002

Default No. 1 - a) If the actual wastewater flow rate is unknown, add up the wastewater generation factors for each process module. These wastewater generation factors are based on the EPA Effluent Guidelines refinery flow model.

b) In the absence of any other reliable data, use 21 gal. of WW per bbl. of crude.

Default No. 2 - a) The emission factors for OWS are:
uncovered - 1.88 lb/10^3 gal. WW
→ covered - 0.38 lb/10^3 gal. WW
covered and vented - 0.06 lb/10^3 gal. WW to a control device

b) If the type of emission control is unknown, assumed that the separator is covered.

Default No. 3 - a) If a DAF unit is known to be present but the wastewater flow rate is unknown, use the value calculated in Default No. 1.

b) If it is not known whether or not a DAF unit is part of the subject facility, assume that no DAF is included.

BOILERS

Emission Calculation

Emission Factor (lb VOC/unit of capacity)		Boiler Capacity (units/day)		VOC Emissions (lb/day)
0.001 lb/10^6 Btu	x	968.1 x 10^6 Btu/day	=	22.1

Defaults

a) The appropriate emission factors are:

- Gas Fired, Utility Boiler* - 0.001 lb/10^6 Btu
  or 1.0 lb/10^6 SCF
- Gas Fired, Industrial Boiler* - 0.0029 lb/10^6 Btu
  or 3.0 lb/10^6 SCF
- Oil Fired, Any Capacity -0.00667 lb/10^6 Btu
  or 1.0 lb/10^3 Gal.
- Coal Fired, Utility Boiler* - 0.3 lb/ton coal**
- Coal Fired, Industrial Boiler* - 1.0 lb/ton coal**

b) If the type of fuel is unknown, use
Gas = 89% , Fuel Oil = 10%, Coal = 1%.

c) If the boiler capacity is unknown, use
Total Boiler Capacity = 134,000 Btu/Bbl x _____ BPD Crude.

*Utility Boiler ≥ 100 x 10^6 Btu/hr., Industrial Boiler < 100 x 10^6 Btu/hr.

**Emission factors good for Bituminous and Lignite coals only, VOC emissions from Anthracite are negligible.

BOILERS (CONT.)

Emission Calculation

Emission Factor (lb VOC/unit of capacity)		Boiler Capacity (units/day)		VOC Emissions (lb/day)
0.3 lb/VOC/ton	x	396 ton/day	=	118.9

Defaults

a) The appropriate emission factors are:

- Gas Fired, Utility Boiler* - 0.001 lb/10^6 Btu
  or 1.0 lb/10^6 SCF
- Gas Fired, Industrial Boiler* - 0.0029 lb/10^6 Btu
  or 3.0 lb/10^6 SCF
- Oil Fired, Any Capacity -0.00667 lb/10^6 Btu
  or 1.0 lb/10^3 Gal.
- Coal Fired, Utility Boiler* - 0.3 lb/ton coal**
- Coal Fired, Industrial Boiler* - 1.0 lb/ton coal**

b) If the type of fuel is unknown, use
Gas = 89% , Fuel Oil = 10%, Coal = 1%.

c) If the boiler capacity is unknown, use
Total Boiler Capacity = 134,000 Btu/Bbl x _____ BPD Crude.

*Utility Boiler $\geq$ 100 x 10^6 Btu/hr., Industrial Boiler < 100 x 10^6 Btu/hr.

**Emission factors good for Bituminous and Lignite coals only, VOC emissions from Anthracite are negligible.

COOLING TOWERS

		Emissions (lb/day)
165.6	X 6 lb VOC/10^6 gal CW =	993.6
Cooling Water Circulation Rate in 10^6 gal/day		

Defaults a. If the cooling tower circulation rate is unknown, use 1670 gal CW/Bbl crude.

BLOWDOWN SYSTEM AND FLARES

________	X	________	X	________	X	________	X	(1- ________	X	$\frac{1}{379}$	=	1,944 *
Total flare capacity in scfd		Fraction of operating time		Vol. fraction of VOC		Mol. Wt. of the VOC in lb/mole		Fractional Destruction Efficiency				

Defaults a. If the flare capacity is not known, ignore the above equation and use

________ X 0.8 lb VOC/10^3 Bbl = ________

Crude Charge Rate in 10^3 Bbl/day

✓b. If the fraction of operating time is not known, use 0.01.

c. If the volume fraction of VOC in the flared gas is not known, use 0.5.

d. If the molecular weight of the VOC is not known, use 58.

✓e. If the fractional destruction efficiency is not known, use 0.99.

Known: Max rate = $0.81 \times 10^6 \frac{lb}{hr}$ gas to flare

Emissions = $0.81 \times 10^6 \frac{lb}{hr} \times 24 \frac{hr}{day} \times (1-0.99) \times 0.01 = 1944 \frac{lb}{day}$

CASE 2

GREAT PLAINS GASIFICATION PLANT

CASE 2

GREAT PLAINS GASIFICATION PLANT

EMISSION CALCULATION SHEET FOR MODULES SPECIFIC TO SYNFUELS PLANTS

MODULE NAME Gasification

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Aqueous (A)	0.0026	×	69 (see default #1)	=	0.18
Pump Seals	Hydrocarbon Liquid (HL)	0.011	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	4 (see default #2)	=	10.4
Valves	Hydrocarbon Gas (HCG)	0.0042	×	1234 (see default #3)	=	5.2
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Hydrocarbon Liquids (HL)	0.0057	×	68 (see default #3)	=	0.39
Valves	Aqueous (A)	0.0026	×	1610 (see default #3)	=	4.2
Connections	Hydrocarbon Gas (HCG)	0.0005	×	4358 (see default #4)	=	2.2
Connections	Hydrocarbon Liquid (HL)	0.0011	×	292 (see default #4)	=	0.3
Connections	Aqueous (A)	0.00007	×	3128 (see default #4)	=	0.2
Relief Valves	Gas (G)	0.34	×	184 (see default #5)	=	62.6
Relief Valves	Liquid (L)	0.0037	×	0 (see default #5)	=	0
Open End Lines	All	0.12	×	69 (see default #6)	=	8.3
Process Drains	All	1.7	×	115 (see default #7)	=	195
Sample System Purging	All	0.79	×	35 (see default #7c)	=	27.6

Gasification

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	______ (see default #8)	=			0
	Or	3.0 lb/10^6 scf		×		______ (see default #8)	10^6 scf/day =	______
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	______ (see default #8)	=			0
	Or	1.0 lb/10^3 gal		×		______ (see default #8)	10^3 gal/day =	______
Coal		1.0 lb/ton		×		______ (see default #8)	tons/day =	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
______	______ (see default #9)	×	______ (see default #9)	×	______ (see default #9)	× 2.64 × 10^{-9} =	0*
______	______	×	______	×	______	× 2.64 × 10^{-9} =	______
______	______	×	______	×	______	× 2.64 × 10^{-9} =	______

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
______	______ (see default #9)	×	______ (see default #9)	=	______
______	______	×	______	=	______
______	______	×	______	=	______

*Low pressure coal lockhopper vent gases routed to boiler - emission accounted for there

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
______ (see default #10)	______ (see default #10)	=	—	______

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EMISSION CALCULATION SHEET FOR MODULES SPECIFIC TO SYNFUELS PLANTS

MODULE NAME Acid Gas Removal

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Aqueous (A)	0.0026	×	6 (see default #1)	=	–
Pump Seals	Hydrocarbon Liquid (HL)	0.011	×	92 (see default #1)	=	1.0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	0.0042	×	340 (see default #3)	=	1.4
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Hydrocarbon Liquids (HL)	0.0057	×	1090 (see default #3)	=	6.2
Valves	Aqueous (A)	0.0026	×	160 (see default #3)	=	0.4
Connections	Hydrocarbon Gas (HCG)	0.0005	×	1120 (see default #4)	=	0.6
Connections	Hydrocarbon Liquid (HL)	0.0011	×	2920 (see default #4)	=	3.2
Connections	Aqueous (A)	0.00007	×	420 (see default #4)	=	–
Relief Valves	Gas (G)	0.34	×	24 (see default #5)	=	8.2
Relief Valves	Liquid (L)	0.0037	×	4 (see default #5)	=	–
Open End Lines	All	0.12	×	108 (see default #6)	=	13.0
Process Drains	All	1.7	×	156 (see default #7)	=	265
Sample System Purging	All	0.79	×	54 (see default #7c)	=	42.7

AGR

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption	
Gas	Either	0.0029 lb/10^6 Btu	×	(see default #8)	=		0
	Or	3.0 lb/10^6 scf		×		(see default #8) 10^6 scf/day =	
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=		0
	Or	1.0 lb/10^3 gal		×		(see default #8) 10^3 gal/day =	
Coal		1.0 lb/ton		×		(see default #8) tons/day =	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	0*
		×		×		× 2.64×10^{-9} =	
		×		×		× 2.64×10^{-9} =	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	
		×		=	
		×		=	

* H_2S - lean vent gas stream shown routing to gas cooling

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=	—	

70A3244

EMISSION CALCULATION SHEET FOR MODULES SPECIFIC TO SYNFUELS PLANTS

MODULE NAME Wastewater Solvent Extraction

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Aqueous (A)	0.0026	×	14 (see default #1)	=	0.04
Pump Seals	Hydrocarbon Liquid (HL)	0.011	×	16 (see default #1)	=	0.18
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	0.0042	×	74 (see default #3)	=	0.31
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Hydrocarbon Liquids (HL)	0.0057	×	224 (see default #3)	=	1.28
Valves	Aqueous (A)	0.0026	×	418 (see default #3)	=	1.09
Connections	Hydrocarbon Gas (HCG)	0.0005	×	266 (see default #4)	=	0.13
Connections	Hydrocarbon Liquid (HL)	0.0011	×	988 (see default #4)	=	1.09
Connections	Aqueous (A)	0.00007	×	1832 (see default #4)	=	0.13
Relief Valves	Gas (G)	0.34	×	4 (see default #5)	=	1.36
Relief Valves	Liquid (L)	0.0037	×	28 (see default #5)	=	0.1
Open End Lines	All	0.12	×	32 (see default #6)	=	3.84
Process Drains	All	1.7	×	48 (see default #7)	=	81.6
Sample System Purging	All	0.79	×	16 (see default #7c)	=	12.6

WW Solvent Extraction

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	______ (see default #8)	=		0
	Or	3.0 lb/10^6 scf		×	______ (see default #8) 10^6 scf/day	=	______
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	______ (see default #8)	=		0
	Or	1.0 lb/10^3 gal		×	______ (see default #8) 10^3 gal/day	=	______
Coal		1.0 lb/ton		×	______ (see default #8) tons/day	=	0

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
______	______ (see default #9)	×	______ (see default #9)	×	______ (see default #9)	× 2.64×10^{-9} =	0
______	______	×	______	×	______	× 2.64×10^{-9} =	______
______	______	×	______	×	______	× 2.64×10^{-9} =	______

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
______	______ (see default #9)	×	______ (see default #9)	=	______
______	______	×	______	=	______
______	______	×	______	=	______

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
______ (see default #10)	______ (see default #10)	=	—	______

70A3244

BOILERS

Emission Calculation

Emission Factor (lb VOC/unit of capacity)		Boiler Capacity (units/day)		VOC Emissions (lb/day)
0.001 lb /10^6 Btu	x	16,560 x 10^6 Btu/day	=	16.6

Defaults

a) The appropriate emission factors are:

- Gas Fired, Utility Boiler* - 0.001 lb/10^6 Btu
  or 1.0 lb/10^6 SCF
- Gas Fired, Industrial Boiler* - 0.0029 lb/10^6 Btu
  or 3.0 lb/10^6 SCF
- Oil Fired, Any Capacity -0.00667 lb/10^6 Btu
  or 1.0 lb/10^3 Gal.
- Coal Fired, Utility Boiler* - 0.3 lb/ton coal**
- Coal Fired, Industrial Boiler* - 1.0 lb/ton coal**

b) If the type of fuel is unknown, use
Gas = 89% , Fuel Oil = 10%, Coal = 1%.

c) If the boiler capacity is unknown, use
Total Boiler Capacity = 134,000 Btu/Bbl x _____ BPD Crude.

*Utility Boiler $\geq$ 100 x 10^6 Btu/hr., Industrial Boiler < 100 x 10^6 Btu/hr.

**Emission factors good for Bituminous and Lignite coals only, VOC emissions from Anthracite are negligible.

BOILERS (CONT.)

Emission Calculation

Emission Factor (lb VOC/unit of capacity)		Boiler Capacity (units/day)		VOC Emissions (lb/day)
0.0067 lb/10^6 Btu	x	46,680 x 10^6 Btu/day	=	313

Defaults

a) The appropriate emission factors are:

- Gas Fired, Utility Boiler* - 0.001 lb/10^6 Btu
  or 1.0 lb/10^6 SCF
- Gas Fired, Industrial Boiler* - 0.0029 lb/10^6 Btu
  or 3.0 lb/10^6 SCF
- Oil Fired, Any Capacity -0.00667 lb/10^6 Btu
  or 1.0 lb/10^3 Gal.
- Coal Fired, Utility Boiler* - 0.3 lb/ton coal**
- Coal Fired, Industrial Boiler* - 1.0 lb/ton coal**

b) If the type of fuel is unknown, use
Gas = 89% , Fuel Oil = 10%, Coal = 1%.

c) If the boiler capacity is unknown, use
Total Boiler Capacity = 134,000 Btu/Bbl x _____ BPD Crude.

*Utility Boiler $\geq$ 100 x 10^6 Btu/hr., Industrial Boiler < 100 x 10^6 Btu/hr.

**Emission factors good for Bituminous and Lignite coals only, VOC emissions from Anthracite are negligible.

COOLING TOWERS

Emissions (lb/day)

24.7 X 6 lb VOC/10^6 gal CW = 148

Cooling Water Circulation Rate in 10^6 gal/day

Defaults a. If the cooling tower circulation rate is unknown, use 1670 gal CW/Bbl crude.

BLOWDOWN SYSTEM AND FLARES

(1) Emergency flares

488.3×10^6	X	0.01	X	0.00825	X	35.8	X	(1- 0.99	X	$\frac{1}{379}$	=	38
Total flare capacity in scfd		Fraction of operating time		Vol. fraction of VOC		Mol. Wt. of the VOC in lb/mole		Fractional Destruction Efficiency				

Defaults a. If the flare capacity is not known, ignore the above equation and use

__________ X 0.8 lb VOC/10^3 Bbl = ________

Crude Charge Rate in 10^3 Bbl/day

b. If the fraction of operating time is not known, use 0.01.

c. If the volume fraction of VOC in the flared gas is not known, use 0.5.

d. If the molecular weight of the VOC is not known, use 58.

e. If the fractional destruction efficiency is not known, use 0.99.

(2) Low-pressure flare

$$1.33 \times 10^6 \times 1.00 \times 0.036 \times 70.0 \times (1-0.99) \times \frac{1}{379} = 88$$

WASTEWATER TREATING

Oil-Water Separator

Wastewater Flow Rate in 10^3 gal/day (See Default No. 1)		Emission Factor (See Default No. 2)		Emissions (lb/day)
6,377.6	x	0.06	=	383

Dissolved Air Flotation Units

Wastewater Flow Rate in 10^3 gal/day (See Default No. 3)				
0	x	0.09 lb/10^3 gal. WW	=	0

Total Wastewater Emissions = 383
(Sum of the emissions from the OWS and DAF)

Default No. 1 - a) If the actual wastewater flow rate is unknown, add up the wastewater generation factors for each process module. These wastewater generation factors are based on the EPA Effluent Guidelines refinery flow model.

b) In the absence of any other reliable data, use 21 gal. of WW per bbl. of crude.

Default No. 2 - a) The emission factors for OWS are:
uncovered - 1.88 lb/10^3 gal. WW
covered - 0.38 lb/10^3 gal. WW
→ covered and vented - 0.06 lb/10^3 gal. WW to a control device

b) If the type of emission control is unknown, assumed that the separator is covered.

Default No. 3 - a) If a DAF unit is known to be present but the wastewater flow rate is unknown, use the value calculated in Default No. 1.

→ b) If it is not known whether or not a DAF unit is part of the subject facility, assume that no DAF is included.

FIXED ROOF TANK EMISSION CALCULATION SHEET
(See Default 1)

TAR

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68}\ (D)^{1.73}\ (H)^{0.51}\ (\Delta T)^{0.5}\ (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \overset{190}{(M)}\ \left(\frac{0.07}{14.7 - 0.07}\right)^{0.68}\ (80)^{1.73}\ 243^{0.51}\ (24)^{0.5}\ (1.0)(1.0)(1.0)$$

LB = 50.7 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})(190)(0.07)(1.0)(1.0)$$

LW = 0.32 lb/10^3 gal.

where: LW = Fixed roof working loss (lb/10^3 gal. throughput)
M = see above
P = see above
KN = Turnover factor (dimensionless), see Default 2i.
KC = Crude oil factor (dimensionless), see Default 2j.

Working Loss Per Day

LWPD = (LW)(TP) = $\overset{0.32}{(\;)}\;\overset{192.3}{(\;)}$ = 61.4 lb/day

where LWPD = Working loss per day (lb/day)
LW = see above
TP = Average daily throughput (10^3 gal./day), see Default 2k.

Total Emissions Per Tank

TEPT = (LB) + (LWPD) = (50.7) + $\overset{61.4}{(\;\;)}$ = 112.1 lb/day

where TEPT = Total emissions per tank (lb/day)

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(N) = $\overset{112.1}{(\;\;)}\;\overset{2}{(\;\;)}$ = 224.2 lb/day

where TEG = Total emissions for a group of identical tanks (lb/day)
TEPT = see above
N = Number of identical tanks in the facility understudy, see Default 1b.

FIXED ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

TAR OIL

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68}\ (D)^{1.73}\ (H)^{0.51}\ (\Delta T)^{0.5}\ (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \overset{190}{(M)}\ \left(\frac{0.10}{14.7 - 0.10}\right)^{0.68}\ (45)^{1.73}\ (28)^{0.51}\ (24)^{0.5}\ (1.0)(1.0)(1.0)$$

LB = 25.9 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})(190)(0.1)(1.0)(1.0)$$

LW = 0.46 lb/10^3 gal.

FIXED ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

TAR OIL

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68}\ (D)^{1.73}\ (H)^{0.51}\ (\Delta T)^{0.5}\ (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \overset{190}{(M)}\ \left(\frac{0.10}{14.7 - 0.10}\right)^{0.68}\ (45)^{1.73}\ (24.8)^{0.51}\ (24)^{0.5}\ (1.0)(1.0)(1.0)$$

LB = 25.9 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})(190)(0.1)(1.0)(1.0)$$

LW = 0.46 lb/10³ gal.

where: LW = Fixed roof working loss (lb/10^3 gal. throughput)
M = see above
P = see above
KN = Turnover factor (dimensionless), see Default 2i.
KC = Crude oil factor (dimensionless), see Default 2j.

Working Loss Per Day

$\text{LWPD} = (\text{LW})(\text{TP}) = (\overset{0.46}{\ })\ (\overset{70.8}{\ }) = \underline{\quad 32.3 \quad}$ lb/day

where LWPD = Working loss per day (lb/day)
LW = see above
TP = Average daily throughput (10^3 gal./day), see Default 2k.

Total Emissions Per Tank

$\text{TEPT} = (\text{LB}) + (\text{LWPD}) = (\overset{25.9}{\ }) + (\overset{32.3}{\ }) = \underline{\quad 58.2 \quad}$ lb/day

where TEPT = Total emissions per tank (lb/day)

Total Emissions for a Group of Identical Tanks

$\text{TEG} = (\text{TEPT})(\text{N}) = (\overset{58.2}{\ })\ (\overset{2}{\ }) = \underline{\quad 116.4 \quad}$ lb/day

where TEG = Total emissions for a group of identical tanks (lb/day)
TEPT = see above
N = Number of identical tanks in the facility understudy, see Default 1b.

FIXED ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

CRUDE PHENOL

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68}\ (D)^{1.73}\ (H)^{0.51}\ (\Delta T)^{0.5}\ (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \overset{190}{(M)}\ \left(\frac{0.09}{14.7 - 0.09}\right)^{0.68}\ (40)^{1.73}\ \underset{16.7}{(\ \ )}^{0.51}\ (24)^{0.5}\ (1.0)(1.0)(1.0)$$

LB = 16.0 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})(190)(0.09)(1.0)(1.0)$$

LW = 0.41 $lb/10^3$ gal.

where: LW = Fixed roof working loss (lb/10^3 gal. throughput)
M = see above
P = see above
KN = Turnover factor (dimensionless), see Default 2i.
KC = Crude oil factor (dimensionless), see Default 2j.

Working Loss Per Day

LWPD = (LW)(TP) = $\overset{0.41}{(\ )}\ \overset{35.8}{(\ )}$ = 14.7 lb/day

where LWPD = Working loss per day (lb/day)
LW = see above
TP = Average daily throughput (10^3 gal./day), see Default 2k.

Total Emissions Per Tank

TEPT = (LB) + (LWPD) = $\overset{16.0}{(\ \ )} + \overset{14.7}{(\ \ )}$ = 30.7 lb/day

where TEPT = Total emissions per tank (lb/day)

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(N) = $\overset{30.7}{(\ \ )}\ \overset{2}{(\ \ )}$ = 61.4 lb/day

where TEG = Total emissions for a group of identical tanks (lb/day)
TEPT = see above
N = Number of identical tanks in the facility understudy, see Default 1b.

FIXED ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

SLOP OIL

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68} (D)^{1.73} (H)^{0.51} (\Delta T)^{0.5} (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \overset{130}{(M)}\ \left(\frac{.009}{14.7 - .009}\right)^{0.68} \underset{21.4}{(\ )}^{1.73} \underset{8.4}{(\ )}^{0.51} \underset{24}{(\ )}^{0.5} \underset{1.0}{(\ )}\underset{1.0}{(\ )}\underset{1.0}{(\ )}$$

LB = 0.4 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})(130)\overset{.009}{(\ )}\overset{1.0}{(\ )}\overset{1.0}{(\ )}$$

LW = 0.028 lb/10^3 gal.

where: LW = Fixed roof working loss (lb/10^3 gal. throughput)
M = see above
P = see above
KN = Turnover factor (dimensionless), see Default 2i.
KC = Crude oil factor (dimensionless), see Default 2j.

Working Loss Per Day

LWPD = (LW)(TP) = $\overset{0.028}{(\ )}\ \overset{2.8}{(\ )}$ = 0.08 lb/day

where LWPD = Working loss per day (lb/day)
LW = see above
TP = Average daily throughput (10^3 gal./day), see Default 2k.

Total Emissions Per Tank

TEPT = (LB) + (LWPD) = $\overset{0.4}{(\ )} + \overset{0.08}{(\ )}$ = 0.5 lb/day

where TEPT = Total emissions per tank (lb/day)

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(N) = $\overset{0.5}{(\ )}\ \overset{1}{(\ )}$ = 0.5 lb/day

where TEG = Total emissions for a group of identical tanks (lb/day)
TEPT = see above
N = Number of identical tanks in the facility understudy, see Default 1b.

FIXED ROOF TANK EMISSION CALCULATION SHEET
(See Default 1)

FUEL OIL #2

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68}\ (D)^{1.73}\ (H)^{0.51}\ (\Delta T)^{0.5}\ (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \overset{130}{(M)}\ \left(\frac{.009}{14.7 - .009}\right)^{0.68}\ \underset{33.5}{(\quad)}^{1.73}\ \underset{16.6}{(\quad)}^{0.51}\ \underset{24}{(\quad)}^{0.5}\ \underset{1.0}{(\quad)}\underset{1.0}{(\quad)}\underset{1.0}{(\quad)}$$

LB = 1.7 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})\overset{130}{(\quad)}\overset{.009}{(\quad)}\overset{1.0}{(\quad)}\overset{1.0}{(\quad)}$$

LW = 0.028 lb/10³ gal.

where: LW = Fixed roof working loss (lb/10^3 gal. throughput)
M = see above
P = see above
KN = Turnover factor (dimensionless), see Default 2i.
KC = Crude oil factor (dimensionless), see Default 2j.

Working Loss Per Day

LWPD = (LW)(TP) = (0.028) (14.1) = 0.4 lb/day

where LWPD = Working loss per day (lb/day)
LW = see above
TP = Average daily throughput (10^3 gal./day), see Default 2k.

Total Emissions Per Tank

TEPT = (LB) + (LWPD) = (1.7) + (0.4) = 2.1 lb/day

where TEPT = Total emissions per tank (lb/day)

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(N) = (2.1) (1) = 2.1 lb/day

where TEG = Total emissions for a group of identical tanks (lb/day)
TEPT = see above
N = Number of identical tanks in the facility understudy, see Default 1b.

Withdrawal Loss Per Day

$LWDPD = (LWD)(TP) = (\overset{0.11}{\ \ })(\overset{25.8}{\ \ }) = \underline{\ \ 2.9\ \ }$ lb/day

where: LWDPD = Withdrawal loss per day (lb/day)

TP = Average daily throughput (10^3 gal/day), see Default 2k.

Total Emissions Per Tank

$TEPT = (LS) + (LWDPD) = (\overset{1.6}{\ \ }) + (\overset{2.9}{\ \ }) = \underline{\ \ 4.5\ \ }$ lb/day

Total Emissions for a Group of Identical Tanks

$TEG = (TEPT)(\text{No. of Tanks}) = (\overset{4.5}{\ \ })(\overset{2}{\ \ }) = \underline{\ \ 9.0\ \ }$ lb/day

FLOATING ROOF TANK EMISSION CALCULATION SHEET
(See Default 1)

NAPHTHA

Standing Storage Loss

$$LS = (9.21 \times 10^{-3})(M)\left(\frac{P}{14.7 - P}\right)^{0.7} (D)^{1.5} \; (VW)^{0.7} \; (KT)(KS)(KP)(KC)$$

$$LS = (9.21 \times 10^{-3})\underset{65}{(\ )}\left(\frac{4.4}{14.7 - 4.4}\right)^{0.7} \underset{40}{(\ )}^{1.5} \; \underset{11.6}{(\ )}^{0.7} \; \underset{0.11}{(\ )}\underset{1.0}{(\ )}\underset{0.9}{(\ )}\underset{1.0}{(\ )}$$

LS = 46.0 lb/day

where: LS = Floating roof standing storage loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 3a.

VW = Average wind velocity (mi/hr), see Default 3b.

KT = Tank type factor (dimensionless), see Default 3c.

KS = Seal factor (dimensionless), see Default 3d.

KP = Paint factor (dimensionless), see Default 3e.

KC = Crude oil factor (dimensionless), see Default 3f.

Withdrawal Loss

$$LWD = \frac{(22.4)(d)(CF)}{(D)} = \frac{(22.4)\overset{6.4}{(\ )}\overset{0.02}{(\ )}}{\underset{40}{(\ )}}$$

LWD = 0.07 lb/10^3 gal. throughput

where: LWD = Floating roof withdrawal loss (lb/10^3 gal throughput)

d = Density of stored liquid at bulk liquid conditions (lb/gal), see Default 3g.

CF = Tank construction factor (dimensionless), see Default 3h.

D = Tank diameter (ft), see Default 1c.

Withdrawal Loss Per Day

$$LWDPD = (LWD)(TP) = (\overset{0.07}{\quad})(\overset{39.8}{\quad}) = \underline{\quad 2.8 \quad} \text{ lb/day}$$

where: LWDPD = Withdrawal loss per day (lb/day)
TP = Average daily throughput (10^3 gal/day), see Default 2k.

Total Emissions Per Tank

$$TEPT = (LS) + (LWDPD) = (\overset{46.0}{\quad}) + (\overset{2.8}{\quad}) = \underline{\quad 48.8 \quad} \text{ lb/day}$$

Total Emissions for a Group of Identical Tanks

$$TEG = (TEPT)(\text{No. of Tanks}) = (\overset{48.8}{\quad})(\overset{2}{\quad}) = \underline{\quad 97.6 \quad} \text{ lb/day}$$

CASE 3

LARGE EXISTING REFINERY

EMISSION CALCULATION SHEET

MODULE NAME L 13 - Distillation and Light Ends Recovery

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	59 (see default #1)	=	354
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	6 (see default #2)	=	204
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	1602 (see default #3)	=	2243
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	1669 (see default #3)	=	968
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	10 800 (see default #4)	=	140
Relief Valves	Gas (G)	8.6	×	50 (see default #5)	=	430
Relief Valves	Liquid (L)	0.37	×	6 (see default #5)	=	2
Open End Lines	All	0.12	×	103 (see default #6)	=	12
Process Drains	All	1.7	×	40 (see default #7)	=	68
Sample System Purging	All	0.79	×	63 (see default #7C) =	=	50

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EMISSION CALCULATION SHEET (con't) L 13

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	1176 (see default #8)		=	3.4
	Or	3.0 lb/10^6 scf	×		____ (see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	____ (see default #8)		=	—
	Or	1.0 lb/10^3 gal	×		____ (see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×		____ (see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
____	____ (see default #9)	×	____ (see default #9)	×	____ (see default #9)	× 2.64 × 10^{-9} =	—
____	____	×	____	×	____	× 2.64 × 10^{-9} =	—
____	____	×	____	×	____	× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
____	____ (see default #9)	×	____ (see default #9)	=	—
____	____	×	____	=	—
____	____	×	____	=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
____ (see default #10)	____ (see default #10)	=	____	—

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EMISSION CALCULATION SHEET

MODULE NAME L 14 Middle Distillate Hydrotreating

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	2 (see default #1)	=	12
Pump Seals	Heavy Liquid (HL)	1.1	×	12 (see default #1)	=	13
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	4 (see default #2)	=	10
Valves	Hydrocarbon Gas (HCG)	1.4	×	179 (see default #3)	=	250
Valves	Hydrogen Gas (HYD)	0.43	×	264 (see default #3)	=	114
Valves	Light Liquids (LL)	0.58	×	58 (see default #3)	=	34
Valves	Heavy Liquids (HL)	0.012	×	454 (see default #3)	=	5
Connections	All	0.013	×	2820 (see default #4)	=	37
Relief Valves	Gas (G)	8.6	×	14 (see default #5)	=	120
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	40 (see default #6)	=	5
Process Drains	All	1.7	×	24 (see default #7)	=	41
Sample System Purging	All	0.79	×	16 (see default #7C) =	=	13

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EMISSION CALCULATION SHEET (con't) L14 - HDS

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	984 (see default #8)		=	3.
	Or	3.0 lb/10^6 scf	×		(see default #8) 10^6 scf/day	=	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)		=	—
	Or	1.0 lb/10^3 gal	×		(see default #8) 10^3 gal/day	=	—
Coal		1.0 lb/ton	×		(see default #8) tons/day	=	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 14 Catalytic Reformer

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	8 (see default #1)	=	48
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	102 (see default #3)	=	143
Valves	Hydrogen Gas (HYD)	0.43	×	79 (see default #3)	=	34
Valves	Light Liquids (LL)	0.58	×	605 (see default #3)	=	351
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	2585 (see default #4)	=	34
Relief Valves	Gas (G)	8.6	×	11 (see default #5)	=	95
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	34 (see default #6)	=	4
Process Drains	All	1.7	×	16 (see default #7)	=	27
Sample System Purging	All	0.79	×	18 (see default #7C) =	=	14

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EMISSION CALCULATION SHEET (con't) L14 - Reformer

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	6672 (see default #8)		=	19
	Or	3.0 lb/10^6 scf	×		(see default #8) 10^6 scf/day	=	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)		=	—
	Or	1.0 lb/10^3 gal	×		(see default #8) 10^3 gal/day	=	—
Coal		1.0 lb/ton	×		(see default #8) tons/day	=	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)		Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)		(see default #10)	=		—

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EMISSION CALCULATION SHEET

MODULE NAME L 15 Naphtha Hydrotreater

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	22 (see default #1)	=	132
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	202 (see default #3)	=	283
Valves	Hydrogen Gas (HYD)	0.43	×	202 (see default #3)	=	87
Valves	Light Liquids (LL)	0.58	×	945 (see default #3)	=	548
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	4465 (see default #4)	=	58
Relief Valves	Gas (G)	8.6	×	21 (see default #5)	=	181
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	69 (see default #6)	=	8
Process Drains	All	1.7	×	40 (see default #7)	=	68
Sample System Purging	All	0.79	×	29 (see default #7C) =	=	23

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EMISSION CALCULATION SHEET (con't) L15

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	1255 (see default #8)	=			4.
	Or	3.0 lb/10^6 scf	×			(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal	×			(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×			(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

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EMISSION CALCULATION SHEET

MODULE NAME L 16 Middle Distillate Hydrotreater

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	9 (see default #1)	=	54
Pump Seals	Heavy Liquid (HL)	1.1	×	13 (see default #1)	=	14
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	351 (see default #3)	=	491
Valves	Hydrogen Gas (HYD)	0.43	×	519 (see default #3)	=	223
Valves	Light Liquids (LL)	0.58	×	329 (see default #3)	=	191
Valves	Heavy Liquids (HL)	0.012	×	475 (see default #3)	=	6
Connections	All	0.013	×	5405 (see default #4)	=	70
Relief Valves	Gas (G)	8.6	×	26 (see default #5)	=	224
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	73 (see default #6)	=	9
Process Drains	All	1.7	×	31 (see default #7)	=	53
Sample System Purging	All	0.79	×	42 (see default #7C) =	=	33

EMISSION CALCULATION SHEET (con't) L 16

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	14309 (see default #8)	=			41
	Or	3.0 lb/10^6 scf		×		____ (see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	____ (see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		____ (see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		____ (see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
____	____ (see default #9)	×	____ (see default #9)	×	____ (see default #9)	× 2.64 × 10^{-9} =	—
____	____	×	____	×	____	× 2.64 × 10^{-9} =	—
____	____	×	____	×	____	× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
____	____ (see default #9)	×	____ (see default #9)	=	—
____	____	×	____	=	—
____	____	×	____	=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
____ (see default #10)	____ (see default #10)	=	____	—

EMISSION CALCULATION SHEET

MODULE NAME L17 - Hydrogen Production

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	3 (see default #1)	=	18
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	173 (see default #3)	=	242
Valves	Hydrogen Gas (HYD)	0.43	×	197 (see default #3)	=	85
Valves	Light Liquids (LL)	0.58	×	2097 (see default #3)	=	1216
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	8225 (see default #4)	=	107
Relief Valves	Gas (G)	8.6	×	32 (see default #5)	=	275
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	59 (see default #6)	=	7
Process Drains	All	1.7	×	13 (see default #7)	=	22
Sample System Purging	All	0.79	×	46 (see default #7C)	=	36

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EMISSION CALCULATION SHEET (con't) L 17

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption	
Gas	Either	0.0029 lb/10^6 Btu	×	13 368 (see default #8)	=	39
	Or	3.0 lb/10^6 scf	×		(see default #8) 10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=	—
	Or	1.0 lb/10^3 gal	×		(see default #8) 10^3 gal/day =	—
Coal		1.0 lb/ton	×		(see default #8) tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

EMISSION CALCULATION SHEET

MODULE NAME L 18 Hydrogen Production

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	3 (see default #1)	=	18
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	32 (see default #3)	=	45
Valves	Hydrogen Gas (HYD)	0.43	×	36 (see default #3)	=	15
Valves	Light Liquids (LL)	0.58	×	382 (see default #3)	=	222
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	1175 (see default #4)	=	15
Relief Valves	Gas (G)	8.6	×	11 (see default #5)	=	95
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	29 (see default #6)	=	3
Process Drains	All	1.7	×	13 (see default #7)	=	22
Sample System Purging	All	0.79	×	16 (see default #7C) =	=	13

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EMISSION CALCULATION SHEET (con't) L 18

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	15096 (see default #8)	=			44.
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

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EMISSION CALCULATION SHEET

MODULE NAME L 23 Naphtha Hydrotreater

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	22 (see default #1)	=	132
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	202 (see default #3)	=	283
Valves	Hydrogen Gas (HYD)	0.43	×	202 (see default #3)	=	87
Valves	Light Liquids (LL)	0.58	×	945 (see default #3)	=	548
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	4465 (see default #4)	=	58
Relief Valves	Gas (G)	8.6	×	21 (see default #5)	=	181
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	69 (see default #6)	=	8
Process Drains	All	1.7	×	40 (see default #7)	=	68
Sample System Purging	All	0.79	×	29 (see default #7C) =	=	23

EMISSION CALCULATION SHEET (con't) L23

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	1255 (see default #8)		=	4
	Or	3.0 lb/10^6 scf	×		(see default #8) 10^6 scf/day	=	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)		=	—
	Or	1.0 lb/10^3 gal	×		(see default #8) 10^3 gal/day	=	—
Coal		1.0 lb/ton	×		(see default #8) tons/day	=	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

EMISSION CALCULATION SHEET

MODULE NAME L 24 Gas Oil Hydrotreating

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	3 (see default #1)	=	18
Pump Seals	Heavy Liquid (HL)	1.1	×	18 (see default #1)	=	20
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	269 (see default #3)	=	377
Valves	Hydrogen Gas (HYD)	0.43	×	397 (see default #3)	=	171
Valves	Light Liquids (LL)	0.58	×	88 (see default #3)	=	51
Valves	Heavy Liquids (HL)	0.012	×	526 (see default #3)	=	6
Connections	All	0.013	×	4230 (see default #4)	=	55
Relief Valves	Gas (G)	8.6	×	14 (see default #5)	=	120
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	57 (see default #6)	=	7
Process Drains	All	1.7	×	32 (see default #7)	=	54
Sample System Purging	All	0.79	×	25 (see default #7C) =	=	20

70A3243

EMISSION CALCULATION SHEET (con't) L 24

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	3024 (see default #8)		=	9
	Or	3.0 lb/10^6 scf	×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)		=	—
	Or	1.0 lb/10^3 gal	×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

EMISSION CALCULATION SHEET

MODULE NAME L 26 Miscellaneous Fractionation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	0 (see default #1)	=	0
Pump Seals	Heavy Liquid (HL)	1.1	×	11 (see default #1)	=	12
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	57 (see default #3)	=	80
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	0 (see default #3)	=	0
Valves	Heavy Liquids (HL)	0.012	×	515 (see default #3)	=	6
Connections	All	0.013	×	1904 (see default #4)	=	25
Relief Valves	Gas (G)	8.6	×	11 (see default #5)	=	95
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	49 (see default #6)	=	6
Process Drains	All	1.7	×	32 (see default #7)	=	54
Sample System Purging	All	0.79	×	17 (see default #7C) =	=	13

EMISSION CALCULATION SHEET (con't) L26

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	1169 (see default #8)	=			3
	Or	3.0 lb/10^6 scf	×			______ (see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	______ (see default #8)	=			—
	Or	1.0 lb/10^3 gal	×			______ (see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×			______ (see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
______	______ (see default #9)	×	______ (see default #9)	×	______ (see default #9)	× 2.64×10^{-9} =	—
______	______	×	______	×	______	× 2.64×10^{-9} =	—
______	______	×	______	×	______	× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
______	______ (see default #9)	×	______ (see default #9)	=	—
______	______	×	______	=	—
______	______	×	______	=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
______ (see default #10)	______ (see default #10)	=	______	—

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EMISSION CALCULATION SHEET

MODULE NAME L 25 Miscellaneous Fractionation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	3 (see default #1)	=	18
Pump Seals	Heavy Liquid (HL)	1.1	×	17 (see default #1)	=	19
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	85 (see default #3)	=	119
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	115 (see default #3)	=	67
Valves	Heavy Liquids (HL)	0.012	×	565 (see default #3)	=	7
Connections	All	0.013	×	2820 (see default #4)	=	37
Relief Valves	Gas (G)	8.6	×	7 (see default #5)	=	60
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	44 (see default #6)	=	5
Process Drains	All	1.7	×	32 (see default #7)	=	54
Sample System Purging	All	0.79	×	12 (see default #7C) =	=	9

70A3243

EMISSION CALCULATION SHEET (con't) L 25

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	2280 (see default #8)		=	7.
	Or	3.0 lb/10^6 scf	×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)		=	—
	Or	1.0 lb/10^3 gal	×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 28 Atmospheric Crude Distillation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	14 (see default #1)	=	84
Pump Seals	Heavy Liquid (HL)	1.1	×	20 (see default #1)	=	22
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	175 (see default #3)	=	245
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	649 (see default #3)	=	376
Valves	Heavy Liquids (HL)	0.012	×	751 (see default #3)	=	9
Connections	All	0.013	×	5805 (see default #4)	=	75
Relief Valves	Gas (G)	8.6	×	23 (see default #5)	=	198
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	98 (see default #6)	=	12
Process Drains	All	1.7	×	61 (see default #7)	=	104
Sample System Purging	All	0.79	×	37 (see default #7C) =	=	29

70A3243

EMISSION CALCULATION SHEET (con't) L 28 - Atmospheric

COMBUSTION EMISSIONS

Fuel Type		Emission Factor	Heater Duty (10^6 Btu/day)	Fuel Consumption	
Gas	Either	0.0029 lb/10^6 Btu ×	5472 (see default #8) =		16
	Or	3.0 lb/10^6 scf	×	(see default #8) 10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu ×	(see default #8) =		—
	Or	1.0 lb/10^3 gal	×	(see default #8) 10^3 gal/day =	—
Coal		1.0 lb/ton	×	(see default #8) tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.008 (see default #10)	150 (see default #10)	=	1.2	—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 28 Vacuum Crude Distillation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	0 (see default #1)	=	0
Pump Seals	Heavy Liquid (HL)	1.1	×	18 (see default #1)	=	20
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	95 (see default #3)	=	133
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	0 (see default #3)	=	0
Valves	Heavy Liquids (HL)	0.012	×	855 (see default #3)	=	10
Connections	All	0.013	×	3125 (see default #4)	=	41
Relief Valves	Gas (G)	8.6	×	8 (see default #5)	=	69
Relief Valves	Liquid (L)	0.37	×	6 (see default #5)	=	2
Open End Lines	All	0.12	×	56 (see default #6)	=	7
Process Drains	All	1.7	×	36 (see default #7)	=	61
Sample System Purging	All	0.79	×	20 (see default #7C) =	=	16

70A3243

EMISSION CALCULATION SHEET (con't) L28- Vacuum

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	3062 (see default #8)		=	9
	Or	3.0 lb/10^6 scf	×		(see default #8) 10^6 scf/day	=	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)		=	—
	Or	1.0 lb/10^3 gal	×		(see default #8) 10^3 gal/day	=	—
Coal		1.0 lb/ton	×		(see default #8) tons/day	=	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)			
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9}	=	
		×		×		× 2.64×10^{-9}	=	
		×		×		× 2.64×10^{-9}	=	

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
Vacuum Vent Barometric Cond.	18 lb/10^3 Bbl. (see default #9)	×	54 (see default #9)	=	972
		×		=	
		×		=	

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.004 (see default #10)	54 (see default #10)	=	0.22	—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 29 Catalytic Reformer

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	12 (see default #1)	=	72
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	102 (see default #3)	=	143
Valves	Hydrogen Gas (HYD)	0.43	×	79 (see default #3)	=	34
Valves	Light Liquids (LL)	0.58	×	605 (see default #3)	=	351
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	2585 (see default #4)	=	34
Relief Valves	Gas (G)	8.6	×	11 (see default #5)	=	95
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	40 (see default #6)	=	5
Process Drains	All	1.7	×	24 (see default #7)	=	41
Sample System Purging	All	0.79	×	16 (see default #7C) =	=	13

70A3243

EMISSION CALCULATION SHEET (con't) L29

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	6684 (see default #8)	=			19.4
	Or	3.0 lb/10^6 scf	×			(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal	×			(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×			(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

EMISSION CALCULATION SHEET

MODULE NAME L30 Resid Hydrodesulfurizer

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	0 (see default #1)	=	0
Pump Seals	Heavy Liquid (HL)	1.1	×	12 (see default #1)	=	13
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	4 (see default #2)	=	10
Valves	Hydrocarbon Gas (HCG)	1.4	×	24 (see default #3)	=	33
Valves	Hydrogen Gas (HYD)	0.43	×	251 (see default #3)	=	108
Valves	Light Liquids (LL)	0.58	×	0 (see default #3)	=	0
Valves	Heavy Liquids (HL)	0.012	×	509 (see default #3)	=	6
Connections	All	0.013	×	2585 (see default #4)	=	34
Relief Valves	Gas (G)	8.6	×	12 (see default #5)	=	103
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	42 (see default #6)	=	5
Process Drains	All	1.7	×	24 (see default #7)	=	41
Sample System Purging	All	0.79	×	18 (see default #7C) =	=	14

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EMISSION CALCULATION SHEET (con't) L 30

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption			
Gas	Either	0.0029 lb/10^6 Btu	×	1469 (see default #8)			=	4
	Or	3.0 lb/10^6 scf		×	(see default #8)	10^6 scf/day	=	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)			=	—
	Or	1.0 lb/10^3 gal		×	(see default #8)	10^3 gal/day	=	—
Coal		1.0 lb/ton		×	(see default #8)	tons/day	=	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)			
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9}	=	—
		×		×		× 2.64×10^{-9}	=	—
		×		×		× 2.64×10^{-9}	=	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 31 Hydrogen Production

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	3 (see default #1)	=	18
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	173 (see default #3)	=	242
Valves	Hydrogen Gas (HYD)	0.43	×	197 (see default #3)	=	85
Valves	Light Liquids (LL)	0.58	×	2097 (see default #3)	=	1216
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	8225 (see default #4)	=	107
Relief Valves	Gas (G)	8.6	×	32 (see default #5)	=	275
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	59 (see default #6)	=	7
Process Drains	All	1.7	×	13 (see default #7)	=	22
Sample System Purging	All	0.79	×	46 (see default #7C) =	=	36

EMISSION CALCULATION SHEET (con't) L31

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	13 368 (see default #8) =			39
	Or	3.0 lb/10^6 scf		×	(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8) =			—
	Or	1.0 lb/10^3 gal		×	(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×	(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 32 Alkylation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	27 (see default #1)	=	162
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	2 (see default #2)	=	68
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	232 (see default #3)	=	325
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	1554 (see default #3)	=	901
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	5875 (see default #4)	=	76
Relief Valves	Gas (G)	8.6	×	15 (see default #5)	=	129
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	77 (see default #6)	=	9
Process Drains	All	1.7	×	47 (see default #7)	=	80
Sample System Purging	All	0.79	×	30 (see default #7C) =	=	24

70A3243

EMISSION CALCULATION SHEET (con't) L32 - Alkylation

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	2026 (see default #8)		=	6
	Or	3.0 lb/10^6 scf	×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)		=	—
	Or	1.0 lb/10^3 gal	×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 32 Polymerization

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	15 (see default #1)	=	80
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	299 (see default #3)	=	419
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	556 (see default #3)	=	322
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	2820 (see default #4)	=	37
Relief Valves	Gas (G)	8.6	×	11 (see default #5)	=	95
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	48 (see default #6)	=	6
Process Drains	All	1.7	×	29 (see default #7)	=	49
Sample System Purging	All	0.79	×	19 (see default #7C) =	=	15

70A3243

EMISSION CALCULATION SHEET (con't) L32 - Polymerization

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption			
Gas	Either	0.0029 lb/10^6 Btu	×	______ (see default #8)	=				——
	Or	3.0 lb/10^6 scf		×		______ (see default #8)	10^6 scf/day	=	——
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	______ (see default #8)	=				——
	Or	1.0 lb/10^3 gal		×		______ (see default #8)	10^3 gal/day	=	——
Coal		1.0 lb/ton		×		______ (see default #8)	tons/day	=	——

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
______	______ (see default #9)	×	______ (see default #9)	×	______ (see default #9)	× 2.64×10^{-9} =	——
______	______	×	______	×	______	× 2.64×10^{-9} =	——
______	______	×	______	×	______	× 2.64×10^{-9} =	——

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
______	______ (see default #9)	×	______ (see default #9)	=	——
______	______	×	______	=	——
______	______	×	______	=	——

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
______ (see default #10)	______ (see default #10)	=	______	——

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L32 Miscellaneous Fractionation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	14 (see default #1)	=	84
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	71 (see default #3)	=	99
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	639 (see default #3)	=	371
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	2350 (see default #4)	=	31
Relief Valves	Gas (G)	8.6	×	11 (see default #5)	=	95
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	44 (see default #6)	=	5
Process Drains	All	1.7	×	27 (see default #7)	=	46
Sample System Purging	All	0.79	×	17 (see default #7C) =	=	13

70A3243

EMISSION CALCULATION SHEET (con't) L 32 - Fractionation

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	____ (see default #8)	=			—
	Or	3.0 lb/10^6 scf	×			____ (see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	____ (see default #8)	=			—
	Or	1.0 lb/10^3 gal	×			____ (see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×			____ (see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
____	____ (see default #9)	×	____ (see default #9)	×	____ (see default #9)	× 2.64×10^{-9} =	—
____	____	×	____	×	____	× 2.64×10^{-9} =	—
____	____	×	____	×	____	× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
____	____ (see default #9)	×	____ (see default #9)	=	—
____	____	×	____	=	—
____	____	×	____	=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
____ (see default #10)	____ (see default #10)	=	____	—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 33 Gas Oil Hydrotreater

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	0 (see default #1)	=	0
Pump Seals	Heavy Liquid (HL)	1.1	×	10 (see default #1)	=	11
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	149 (see default #3)	=	209
Valves	Hydrogen Gas (HYD)	0.43	×	220 (see default #3)	=	95
Valves	Light Liquids (LL)	0.58	×	0 (see default #3)	=	0
Valves	Heavy Liquids (HL)	0.012	×	341 (see default #3)	=	4
Connections	All	0.013	×	2350 (see default #4)	=	31
Relief Valves	Gas (G)	8.6	×	11 (see default #5)	=	95
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	31 (see default #6)	=	4
Process Drains	All	1.7	×	15 (see default #7)	=	26
Sample System Purging	All	0.79	×	16 (see default #7C) =	=	13

70A3243

EMISSION CALCULATION SHEET (con't) L 33

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption	
Gas	Either	0.0029 lb/10^6 Btu	×	800 (see default #8)	=		2
	Or	3.0 lb/10^6 scf		×		____ (see default #8) 10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	____ (see default #8)	=		—
	Or	1.0 lb/10^3 gal		×		____ (see default #8) 10^3 gal/day =	—
Coal		1.0 lb/ton		×		____ (see default #8) tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
____	____ (see default #9)	×	____ (see default #9)	×	____ (see default #9)	× 2.64×10^{-9} =	—
____	____	×	____	×	____	× 2.64×10^{-9} =	—
____	____	×	____	×	____	× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
____	____ (see default #9)	×	____ (see default #9)	=	—
____	____	×	____	=	—
____	____	×	____	=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
____ (see default #10)	____ (see default #10)	=	____	—

EMISSION CALCULATION SHEET

MODULE NAME L 36 Catalytic Reformer

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	24 (see default #1)	=	144
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	6 (see default #2)	=	16
Valves	Hydrocarbon Gas (HCG)	1.4	×	194 (see default #3)	=	272
Valves	Hydrogen Gas (HYD)	0.43	×	149 (see default #3)	=	64
Valves	Light Liquids (LL)	0.58	×	1149 (see default #3)	=	666
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	4935 (see default #4)	=	64
Relief Valves	Gas (G)	8.6	×	16 (see default #5)	=	138
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	78 (see default #6)	=	9
Process Drains	All	1.7	×	48 (see default #7)	=	82
Sample System Purging	All	0.79	×	30 (see default #7C) =	=	24

70A3243

EMISSION CALCULATION SHEET (con't) L36

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	3519 (see default #8)	=			10
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 37 Aromatics Extraction

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	17 (see default #1)	=	102
Pump Seals	Heavy Liquid (HL)	1.1	×	11 (see default #1)	=	12
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	205 (see default #3)	=	287
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	1125 (see default #3)	=	653
Valves	Heavy Liquids (HL)	0.012	×	729 (see default #3)	=	9
Connections	All	0.013	×	6815 (see default #4)	=	89
Relief Valves	Gas (G)	8.6	×	31 (see default #5)	=	267
Relief Valves	Liquid (L)	0.37	×	3 (see default #5)	=	1
Open End Lines	All	0.12	×	82 (see default #6)	=	10
Process Drains	All	1.7	×	53 (see default #7)	=	90
Sample System Purging	All	0.79	×	29 (see default #7C) =	=	23

70A3243

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	1772 (see default #8)	=			5
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 38 Catalytic Cracking

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	22 (see default #1)	=	132
Pump Seals	Heavy Liquid (HL)	1.1	×	29 (see default #1)	=	32
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	8 (see default #2)	=	272
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	842 (see default #3)	=	1179
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	890 (see default #3)	=	516
Valves	Heavy Liquids (HL)	0.012	×	1173 (see default #3)	=	14
Connections	All	0.013	×	9635 (see default #4)	=	125
Relief Valves	Gas (G)	8.6	×	16 (see default #5)	=	138
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	118 (see default #6)	=	14
Process Drains	All	1.7	×	51 (see default #7)	=	87
Sample System Purging	All	0.79	×	67 (see default #7C) =	=	53

EMISSION CALCULATION SHEET (con't) L38

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	2003 (see default #8)	=			6
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
CO Boiler	Neg. (see default #9)	×	(see default #9)	=	Neg.
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.046 (see default #10)	50 (see default #10)	=	2.3	—

EMISSION CALCULATION SHEET
FOR PETHROCHEMICAL PROCESS MODULES

MODULE NAME L 39 Non - Volatile Petrochemical

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	2.6	×	0 (see default #1)	=	0
Pump Seals	Heavy Liquid (HL)	1.1	×	13 (see default #1)	=	14
Compressor Seals	Hydrocarbon Gas (HCG)	12	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	12	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	0.30	×	64 (see default #3)	=	19
Valves	Hydrogen Gas (HYD)	0.30	×	19 (see default #3)	=	6
Valves	Light Liquids (LL)	0.38	×	0 (see default #3)	=	0
Valves	Heavy Liquids (HL)	0.012	×	556 (see default #3)	=	7
Connections	All	0.044	×	2115 (see default #4)	=	93
Relief Valves	Gas (G)	5.5	×	10 (see default #5)	=	55
Relief Valves	Liquid (L)	5.5	×	1 (see default #5)	=	5.5
Open End Lines	All	0.09	×	41 (see default #6)	=	4
Process Drains	All	1.7	×	25 (see default #7)	=	43
Sample System Purging	All	0.79	×	16 (see default #7c)	=	13

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EMISSION CALCULATION SHEET (con't) L 39

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	______ (see default #8)	=			______ —
	Or	3.0 lb/10^6 scf		×		______ (see default #8)	10^6 scf/day =	______ —
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	______ (see default #8)	=			______ —
	Or	1.0 lb/10^3 gal		×		______ (see default #8)	10^3 gal/day =	______ —
Coal		1.0 lb/ton		×		______ (see default #8)	tons/day =	______ —

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
______	______ (see default #9)	×	______ (see default #9)	×	______ (see default #9)	× 2.64×10^{-9} =	______ —
______	______	×	______	×	______	× 2.64×10^{-9} =	______ —
______	______	×	______	×	______	× 2.64×10^{-9} =	______ —

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
______	______ (see default #9)	×	______ (see default #9)	=	______ —
______	______	×	______	=	______ —
______	______	×	______	=	______ —

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
______ (see default #10)	______ (see default #10)	=	______	______ —

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 40 Delayed Coker

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	11 (see default #1)	=	66
Pump Seals	Heavy Liquid (HL)	1.1	×	18 (see default #1)	=	20
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	6 (see default #2)	=	204
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	178 (see default #3)	=	249
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	607 (see default #3)	=	352
Valves	Heavy Liquids (HL)	0.012	×	992 (see default #3)	=	12
Connections	All	0.013	×	5875 (see default #4)	=	76
Relief Valves	Gas (G)	8.6	×	28 (see default #5)	=	241
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	84 (see default #6)	=	10
Process Drains	All	1.7	×	41 (see default #7)	=	70
Sample System Purging	All	0.79	×	43 (see default #7C) =	=	34

70A3243

EMISSION CALCULATION SHEET (con't) L 40

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption	
Gas	Either	0.0029 lb/10^6 Btu	×	4431 (see default #8)	=	13
	Or	3.0 lb/10^6 scf	×		(see default #8) 10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=	—
	Or	1.0 lb/10^3 gal	×		(see default #8) 10^3 gal/day =	—
Coal		1.0 lb/ton	×		(see default #8) tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 50 Asphalt Production

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	0 (see default #1)	=	0
Pump Seals	Heavy Liquid (HL)	1.1	×	2 (see default #1)	=	2
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	0 (see default #3)	=	0
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	0 (see default #3)	=	0
Valves	Heavy Liquids (HL)	0.012	×	300 (see default #3)	=	4
Connections	All	0.013	×	1080 (see default #4)	=	14
Relief Valves	Gas (G)	8.6	×	3 (see default #5)	=	26
Relief Valves	Liquid (L)	0.37	×	3 (see default #5)	=	1
Open End Lines	All	0.12	×	21 (see default #6)	=	3
Process Drains	All	1.7	×	11 (see default #7)	=	19
Sample System Purging	All	0.79	×	10 (see default #7C) =	=	8

70A3243

EMISSION CALCULATION SHEET (con't) L50

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	177 (see default #8)	=			0.5
	Or	3.0 lb/10^6 scf	×			(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal	×			(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×			(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
Air Blowing - Incinerated	Neg (see default #9)	×	(see default #8)	=	Neg
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)		Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.048 (see default #10)		15.7 (see default #10)	=	0.75	

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L52 Non-Volatile Lube Oil

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	0 (see default #1)	=	0
Pump Seals	Heavy Liquid (HL)	1.1	×	9 (see default #1)	=	10
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	0 (see default #3)	=	0
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	0 (see default #3)	=	0
Valves	Heavy Liquids (HL)	0.012	×	841 (see default #3)	=	10
Connections	All	0.013	×	2768 (see default #4)	=	36
Relief Valves	Gas (G)	8.6	×	12 (see default #5)	=	103
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	35 (see default #6)	=	4
Process Drains	All	1.7	×	17 (see default #7)	=	29
Sample System Purging	All	0.79	×	18 (see default #7C) =	=	14

70A3243

EMISSION CALCULATION SHEET (con't)

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	____ (see default #8)	=			—
	Or	3.0 lb/10^6 scf		×		____ (see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	____ (see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		____ (see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		____ (see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
____	____ (see default #9)	×	____ (see default #9)	×	____ (see default #9)	× 2.64×10^{-9} =	—
____	____	×	____	×	____	× 2.64×10^{-9} =	—
____	____	×	____	×	____	× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
____	____ (see default #9)	×	____ (see default #9)	=	—
____	____	×	____	=	—
____	____	×	____	=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.048 (see default #10)	6.9 (see default #10)	=	0.33	—

EMISSION CALCULATION SHEET

MODULE NAME L60 Gasoline Treating

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	3 (see default #1)	=	18
Pump Seals	Heavy Liquid (HL)	1.1	×	9 (see default #1)	=	10
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	28 (see default #3)	=	40
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	293 (see default #3)	=	170
Valves	Heavy Liquids (HL)	0.012	×	244 (see default #3)	=	3
Connections	All	0.013	×	1880 (see default #4)	=	24
Relief Valves	Gas (G)	8.6	×	7 (see default #5)	=	60
Relief Valves	Liquid (L)	0.37	×	1 (see default #5)	=	0.4
Open End Lines	All	0.12	×	33 (see default #6)	=	4
Process Drains	All	1.7	×	20 (see default #7)	=	34
Sample System Purging	All	0.79	×	13 (see default #7C) =	=	10

70A3243

EMISSION CALCULATION SHEET (con't) L 60

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	____ (see default #8)	=			—
	Or	3.0 lb/10^6 scf		×		____ (see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	____ (see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		____ (see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		____ (see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name		Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
____		____ (see default #9)	×	____ (see default #9)	×	____ (see default #9)	× 2.64×10^{-9} =	—
____		____	×	____	×	____	× 2.64×10^{-9} =	—
____		____	×	____	×	____	× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
____	____ (see default #9)	×	____ (see default #9)	=	—
____	____	×	____	=	—
____	____	×	____	=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
____ (see default #10)	____ (see default #10)	=	____	—

EMISSION CALCULATION SHEET (con't) L 60

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)	Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	______ (see default #8)		=	—
	Or	3.0 lb/10^6 scf	×		______ (see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	______ (see default #8)		=	—
	Or	1.0 lb/10^3 gal	×		______ (see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton	×		______ (see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
______	______ (see default #9)	×	______ (see default #9)	×	______ (see default #9)	× 2.64×10^{-9} =	—
______	______	×	______	×	______	× 2.64×10^{-9} =	—
______	______	×	______	×	______	× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
______	______ (see default #9)	×	______ (see default #9)	=	—
______	______	×	______	=	—
______	______	×	______	=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
______ (see default #10)	______ (see default #10)	=	______	—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 60 Atmospheric Crude Distillation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	14 (see default #1)	=	84
Pump Seals	Heavy Liquid (HL)	1.1	×	20 (see default #1)	=	22
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	175 (see default #3)	=	245
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	649 (see default #3)	=	376
Valves	Heavy Liquids (HL)	0.012	×	751 (see default #3)	=	9
Connections	All	0.013	×	5805 (see default #4)	=	75
Relief Valves	Gas (G)	8.6	×	23 (see default #5)	=	198
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	98 (see default #6)	=	12
Process Drains	All	1.7	×	61 (see default #7)	=	104
Sample System Purging	All	0.79	×	37 (see default #7C) =	=	29

70A3243

EMISSION CALCULATION SHEET (con't) L 60 - Atmospheric

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	5472 (see default #8)	=			16
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.008 (see default #10)	150 (see default #10)	=	1.2	—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 60 Vacuum Crude Distillation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	0 (see default #1)	=	0
Pump Seals	Heavy Liquid (HL)	1.1	×	18 (see default #1)	=	20
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	95 (see default #3)	=	133
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	0 (see default #3)	=	0
Valves	Heavy Liquids (HL)	0.012	×	855 (see default #3)	=	10
Connections	All	0.013	×	3125 (see default #4)	=	41
Relief Valves	Gas (G)	8.6	×	8 (see default #5)	=	69
Relief Valves	Liquid (L)	0.37	×	6 (see default #5)	=	2
Open End Lines	All	0.12	×	56 (see default #6)	=	7
Process Drains	All	1.7	×	36 (see default #7)	=	61
Sample System Purging	All	0.79	×	20 (see default #7C) =	=	16

70A3243

EMISSION CALCULATION SHEET (con't) L 60 Vacuum

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	3062 (see default #8)	=			9
	Or	3.0 lb/10^6 scf	×			(see default #8) 10^6 scf/day	=	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal	×			(see default #8) 10^3 gal/day	=	—
Coal		1.0 lb/ton	×			(see default #8) tons/day	=	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—
		×		×		× 2.64 × 10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
Vacuum Vent Surface Cond.	Neg. (see default #9)	×	(see default #9)	=	Neg.
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.004 (see default #10)	54 (see default #10)	=	0.22	—

EMISSION CALCULATION SHEET

MODULE NAME L 61 Atmospheric Crude Distillation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	14 (see default #1)	=	84
Pump Seals	Heavy Liquid (HL)	1.1	×	18 (see default #1)	=	20
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	163 (see default #3)	=	228
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	642 (see default #3)	=	372
Valves	Heavy Liquids (HL)	0.012	×	662 (see default #3)	=	8
Connections	All	0.013	×	5390 (see default #4)	=	70
Relief Valves	Gas (G)	8.6	×	26 (see default #5)	=	224
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	91 (see default #6)	=	11
Process Drains	All	1.7	×	56 (see default #7)	=	95
Sample System Purging	All	0.79	×	35 (see default #7C) =	=	28

70A3243

EMISSION CALCULATION SHEET (con't) L 61 Atmospheric

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	2507 (see default #8)	=			7
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.008 (see default #10)	40 (see default #10)	=	0.32	—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 61 Vacuum Crude Distillation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	0 (see default #1)	=	0
Pump Seals	Heavy Liquid (HL)	1.1	×	20 (see default #1)	=	22
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	100 (see default #3)	=	140
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	0 (see default #3)	=	0
Valves	Heavy Liquids (HL)	0.012	×	900 (see default #3)	=	11
Connections	All	0.013	×	3305 (see default #4)	=	43
Relief Valves	Gas (G)	8.6	×	15 (see default #5)	=	129
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	61 (see default #6)	=	7
Process Drains	All	1.7	×	40 (see default #7)	=	68
Sample System Purging	All	0.79	×	21 (see default #7C) =	=	17

70A3243

EMISSION CALCULATION SHEET (con't) L61 Vacuum

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	1190 (see default #8)	=			3
	Or	3.0 lb/10^6 scf		×		(see default #8) 10^6 scf/day	=	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8) 10^3 gal/day	=	—
Coal		1.0 lb/ton		×		(see default #8) tons/day	=	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
Vacuum Vent Surface Cond.	Neg. (see default #9)	×	(see default #9)	=	Neg.
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.004 (see default #10)	14.4 (see default #10)	=	0.057	—

70A3244

EMISSION CALCULATION SHEET

MODULE NAME L 62 Atmospheric Crude Distillation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	7 (see default #1)	=	42
Pump Seals	Heavy Liquid (HL)	1.1	×	8 (see default #1)	=	9
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	78 (see default #3)	=	109
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	328 (see default #3)	=	190
Valves	Heavy Liquids (HL)	0.012	×	297 (see default #3)	=	4
Connections	All	0.013	×	2585 (see default #4)	=	34
Relief Valves	Gas (G)	8.6	×	11 (see default #5)	=	95
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	45 (see default #6)	=	5
Process Drains	All	1.7	×	27 (see default #7)	=	46
Sample System Purging	All	0.79	×	18 (see default #7C) =	=	14

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EMISSION CALCULATION SHEET (con't) L62

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	2127 (see default #8)	=			6
	Or	3.0 lb/10^6 scf		×		(see default #8) 10^6 scf/day	=	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8) 10^3 gal/day	=	—
Coal		1.0 lb/ton		×		(see default #8) tons/day	=	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.008 (see default #10)	10 (see default #10)	=	0.08	—

EMISSION CALCULATION SHEET

MODULE NAME L63 Atmospheric Crude Distillation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	7 (see default #1)	=	42
Pump Seals	Heavy Liquid (HL)	1.1	×	8 (see default #1)	=	9
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	0 (see default #2)	=	0
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	78 (see default #3)	=	109
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	328 (see default #3)	=	190
Valves	Heavy Liquids (HL)	0.012	×	297 (see default #3)	=	4
Connections	All	0.013	×	2585 (see default #4)	=	34
Relief Valves	Gas (G)	8.6	×	11 (see default #5)	=	95
Relief Valves	Liquid (L)	0.37	×	2 (see default #5)	=	1
Open End Lines	All	0.12	×	45 (see default #6)	=	5
Process Drains	All	1.7	×	27 (see default #7)	=	46
Sample System Purging	All	0.79	×	18 (see default #7C) =	=	14

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EMISSION CALCULATION SHEET (con't) LC3

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	2127 (see default #8)	=			6
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
0.008 (see default #10)	10 (see default #10)	=	0.08	—

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EMISSION CALCULATION SHEET

MODULE NAME L 64 Miscellaneous Fractionation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	43 (see default #1)	=	258
Pump Seals	Heavy Liquid (HL)	1.1	×	0 (see default #1)	=	0
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	2 (see default #2)	=	68
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	327 (see default #3)	=	458
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	2947 (see default #3)	=	1709
Valves	Heavy Liquids (HL)	0.012	×	0 (see default #3)	=	0
Connections	All	0.013	×	10 800 (see default #4)	=	140
Relief Valves	Gas (G)	8.6	×	35 (see default #5)	=	301
Relief Valves	Liquid (L)	0.37	×	3 (see default #5)	=	1
Open End Lines	All	0.12	×	152 (see default #6)	=	18
Process Drains	All	1.7	×	82 (see default #7)	=	139
Sample System Purging	All	0.79	×	70 (see default #7C) =	=	55

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EMISSION CALCULATION SHEET (con't) L64

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	879 (see default #8)	=			3
	Or	3.0 lb/10^6 scf		×		(see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	(see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		(see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		(see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
	(see default #9)	×	(see default #9)	×	(see default #9)	× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—
		×		×		× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
	(see default #9)	×	(see default #9)	=	—
		×		=	—
		×		=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
(see default #10)	(see default #10)	=		—

EMISSION CALCULATION SHEET

MODULE NAME L68 Light Ends Recovery and Distillation

FUGITIVE EMISSIONS

Source Type	Service (abb.)	Emission Factor (lb/day/source)		Population (# of sources)		Emissions (lb/day)
Pump Seals	Light Liquid (LL)	6.0	×	20 (see default #1)	=	120
Pump Seals	Heavy Liquid (HL)	1.1	×	3 (see default #1)	=	3
Compressor Seals	Hydrocarbon Gas (HCG)	34.0	×	6 (see default #2)	=	204
Compressor Seals	Hydrogen Gas (HYD)	2.6	×	0 (see default #2)	=	0
Valves	Hydrocarbon Gas (HCG)	1.4	×	802 (see default #3)	=	1122
Valves	Hydrogen Gas (HYD)	0.43	×	0 (see default #3)	=	0
Valves	Light Liquids (LL)	0.58	×	725 (see default #3)	=	421
Valves	Heavy Liquids (HL)	0.012	×	109 (see default #3)	=	1
Connections	All	0.013	×	5405 (see default #4)	=	70
Relief Valves	Gas (G)	8.6	×	28 (see default #5)	=	241
Relief Valves	Liquid (L)	0.37	×	3 (see default #5)	=	1
Open End Lines	All	0.12	×	74 (see default #6)	=	9
Process Drains	All	1.7	×	40 (see default #7)	=	68
Sample System Purging	All	0.79	×	34 (see default #7C) =	=	27

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EMISSION CALCULATION SHEET (con't) L68

COMBUSTION EMISSIONS

Fuel Type		Emission Factor		Heater Duty (10^6 Btu/day)		Fuel Consumption		
Gas	Either	0.0029 lb/10^6 Btu	×	____ (see default #8)	=			—
	Or	3.0 lb/10^6 scf		×		____ (see default #8)	10^6 scf/day =	—
Fuel Oil	Either	0.00667 lb/10^6 Btu	×	____ (see default #8)	=			—
	Or	1.0 lb/10^3 gal		×		____ (see default #8)	10^3 gal/day =	—
Coal		1.0 lb/ton		×		____ (see default #8)	tons/day =	—

POINT SOURCE EMISSIONS

Vent or Stack Name	Vent Rate (scfd)		VOC Concentration (ppmv)		VOC Molecular Weight (lb/mol.)		
____	____ (see default #9)	×	____ (see default #9)	×	____ (see default #9)	× 2.64×10^{-9} =	—
____	____	×	____	×	____	× 2.64×10^{-9} =	—
____	____	×	____	×	____	× 2.64×10^{-9} =	—

Vent or Stack Name	Emission Factor (lb/unit)		Capacity (units/day)		
____	____ (see default #9)	×	____ (see default #9)	=	—
____	____	×	____	=	—
____	____	×	____	=	—

WASTEWATER GENERATION

Wastewater Generation Factor (10^6 gal•ww/10^3 Bbl Cap.)	Capacity (10^3 Bbl/day)		Wastewater Flow (10^6 gal/day)	
____ (see default #10)	____ (see default #10)	=	____	—

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BOILERS

Emission Calculation

Emission Factor (lb VOC/unit of capacity)		Boiler Capacity (units/day)		VOC Emissions (lb/day)
0.001 lb/10^6 Btu	x	25.27 x 10^9 Btu/day	=	25.3

Defaults

a) The appropriate emission factors are:

- Gas Fired, Utility Boiler* - 0.001 lb/10^6 Btu
  or 1.0 lb/10^6 SCF
- Gas Fired, Industrial Boiler* - 0.0029 lb/10^6 Btu
  or 3.0 lb/10^6 SCF
- Oil Fired, Any Capacity -0.00667 lb/10^6 Btu
  or 1.0 lb/10^3 Gal.
- Coal Fired, Utility Boiler* - 0.3 lb/ton coal**
- Coal Fired, Industrial Boiler* - 1.0 lb/ton coal**

b) If the type of fuel is unknown, use
Gas = 89% , Fuel Oil = 10%, Coal = 1%.

c) If the boiler capacity is unknown, use
Total Boiler Capacity = 134,000 Btu/Bbl x _____ BPD Crude.

*Utility Boiler ≥ 100 x 10^6 Btu/hr., Industrial Boiler < 100 x 10^6 Btu/hr.

**Emission factors good for Bituminous and Lignite coals only, VOC emissions from Anthracite are negligible.

WASTEWATER TREATING

Oil-Water Separator

Emissions
(lb/day)

6615
Wastewater Flow Rate in 10^3 gal/day
(See Default No. 1)
x
0.38
Emission Factor
(See Default No. 2)
= 2514

Dissolved Air Flotation Units

125.8
Wastewater Flow Rate in 10^3 gal/day
(See Default No. 3)
x 0.09 lb/10^3 gal. WW
= 11

Total Wastewater Emissions
(Sum of the emissions from the OWS and DAF)
= 2525

Default No. 1 - a) If the actual wastewater flow rate is unknown, add up the wastewater generation factors for each process module. These wastewater generation factors are based on the EPA Effluent Guidelines refinery flow model.

b) In the absence of any other reliable data, use 21 gal. of WW per bbl. of crude.

Default No. 2 - a) The emission factors for OWS are:
uncovered - 1.88 lb/10^3 gal. WW
covered - 0.38 lb/10^3 gal. WW
covered and vented - 0.06 lb/10^3 gal. WW to a control device

b) If the type of emission control is unknown, assumed that the separator is covered.

Default No. 3 - a) If a DAF unit is known to be present but the wastewater flow rate is unknown, use the value calculated in Default No. 1.

b) If it is not known whether or not a DAF unit is part of the subject facility, assume that no DAF is included.

COOLING TOWERS

Emissions
(lb/day)

$$\underset{\text{Cooling Water Circulation Rate in } 10^6 \text{ gal/day}}{\underline{\quad 0.53 \quad}} \times 6 \text{ lb VOC}/10^6 \text{ gal CW} = \underline{\quad 3 \quad}$$

Defaults a. If the cooling tower circulation rate is unknown, use 1670 gal CW/10^3 Bbl crude.

BLOWDOWN SYSTEM AND FLARES

$$\underset{\substack{\text{Total}\\ \text{flare}\\ \text{capacity}\\ \text{in scfd}}}{\underline{\qquad}} \times \underset{\substack{\text{Fraction}\\ \text{of}\\ \text{operating}\\ \text{time}}}{\underline{\qquad}} \times \underset{\substack{\text{Vol.}\\ \text{fraction}\\ \text{of VOC}}}{\underline{\qquad}} \times \underset{\substack{\text{Mol. Wt.}\\ \text{of the}\\ \text{VOC in}\\ \text{lb/mole}}}{\underline{\qquad}} \times \underset{\substack{\text{Fractional}\\ \text{Destruction}\\ \text{Efficiency}}}{\underline{(1- \qquad}} \times \frac{1}{379} = \underline{\quad — \quad}$$

Defaults a. If the input data for the above equation are not known, use

$$\underset{\text{Crude Charge Rate in } 10^3 \text{ Bbl/day}}{\underline{\quad 315 \quad}} \times 0.8 \text{ lb VOC}/10^3 \text{ Bbl} = \underline{\quad 252 \quad}$$

PRODUCT LOADING OPERATIONS

TANK TRUCKS/CARS

Emissions (lb/day)

Gasoline

961 X EF in lb VOC/10^3 gal = 4805

Annual Average Amount of Gasoline Loaded in 10^3 gal/day (see Default Ia)

where EF = [✓ 5.0] for submerged loading-normal service
EF = 12.0 for splash loading-normal service
EF = 8.0 for submerged loading-vapor balance
EF = 8.0 for splash loading-vapor balance
(see Default IIa)

Jet Naphtha

364 X EF in lb VOC/10^3 gal = 546

Annual Average Amount of Jet Naphtha Loaded in 10^3 gal/day (see Default Ib)

where EF = [✓ 1.5] for submerged loading-normal service
EF = 4.0 for splash loading-normal service
EF = 2.5 for submerged loading-vapor balance
EF = 2.5 for splash loading-vapor balance
(see Default IIb)

Kerosene

949 X EF in lb VOC/10^3 gal = 19

Annual Average Amount of Kerosene Loaded in 10^3 gal/day (see Default Ic)

where EF = [✓ 0.02] for submerged loading
EF = 0.04 for splash loading
(see Default IIc)

No. 2 Fuel Oil

314 X EF in lb VOC/10^3 gal = 3

Annual Average Amount of No. 2 F.O. Loaded in 10^3 gal/day (see Default Id)

where EF = [✓ 0.01] for submerged loading
EF = 0.03 for splash loading
(see Default IId)

No. 6 Fuel Oil

314 X EF in lb VOC/10^3 gal = Neg.

Annual Average Amount of No. 6 F.O. Loaded in 10^3 gal/day (see Default Ie)

where EF = [✓ 0.0001] for submerged loading
EF = 0.0003 for splash loading
(see Default IIe)

PRODUCT LOADING OPERATIONS (Continued)

MARINE BARGES Emissions (lb/day)

Gasoline

______ X EF in lb/10^3 gal = ______

Annual Average Amount of Gasoline Loaded in 10^3 gal/day (see Default If)

where EF = 1.2 for barges-cleaned and vapor free
EF = 4.0 for barges-uncleaned (dedicated service)
EF = 4.0 for barges-average condition
EF = 1.3 for ocean barges-cleaned and vapor free
EF = 2.1 for ocean barges-ballasted
EF = 3.3 for ocean barges-uncleaned (dedicated service)
(see Default IIf)

Jet Naphtha

______ X 1.2 lb/10^3 gal = ______

Annual Average Amount of Jet Naphtha Loaded in 10^3 gal/day (see Default Ig)

Kerosene

______ X 0.013 lb/10^3 gal = ______

Annual Average Amount of Kerosene Loaded in 10^3 gal/day (see Default Ih)

No. 2 Fuel Oil

______ X 0.012 lb/10^3 gal = ______

Annual Average Amount of No. 2 F.O. Loaded in 10^3 gal/day (see Default Ii)

No. 6 Fuel Oil

______ X 0.00009 lb/10^3 gal = ______

Annual Average Amount of No. 6 F.O. Loaded in 10^3 gal/day (see Default Ij)

PRODUCT LOADING OPERATIONS (Continued)

MARINE TANKERS

Emissions (lb/day)

Gasoline

— X EF in $lb/10^3$ gal = —

Annual Average Amount of Gasoline Loaded in 10^3 gal/day (see Default Ik)

where EF = 1.0 for cleaned and vapor free
EF = 1.6 for ballasted
EF = 2.4 for uncleaned (dedicated service)
EF = 1.4 for average cargo tank condition
(see Default IIg)

Jet Naphtha

— X 0.5 $lb/10^3$ gal = —

Annual Average Amount of Jet Naphtha Loaded in 10^3 gal/day (see Default Il)

Kerosene

— X 0.005 $lb/10^3$ gal = —

Annual Average Amount of Kerosene Loaded in 10^3 gal/day (see Default Im)

No. 2 Fuel Oil

— X 0.005 $lb/10^3$ gal = —

Annual Average Amount of No. 2 F.O. Loaded in 10^3 gal/day (see Default In)

No. 6 Fuel Oil

— X 0.00004 $lb/10^3$ gal = —

Annual Average Amount of No. 6 F.O. Loaded in 10^3 gal/day (see Default Io)

PRODUCT LOADING OPERATIONS (Continued)

Defaults:

1. If the amounts of each stock loaded are not known, use the following values:

a. Gasoline to Tank Trucks and Cars (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in } 10^3 \text{ BPD}} \times 2.8$

b. Jet Naphtha to Tank Trucks and Cars (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in } 10^3 \text{ BPD}} \times 1.2$

c. Kerosene to Tank Trucks and Cars (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in } 10^3 \text{ BPD}} \times 1.8$

d. No. 2 F.O. to Tank Trucks and Cars (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 1.2$

e. No. 6 F.O. to Tank Trucks and Cars (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 0.7$

f. Gasoline to Barges (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 0.6$

g. Jet Naphtha to Barges (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 0.2$

h. Kerosene to Barges (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 0.3$

i. No. 2 F.O. to Barges (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 0.8$

j. No. 6 F.O. to Barges (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 0.5$

k. Gasoline to Tankers (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 1.1$

l. Jet Naphtha to Tankers (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 0.4$

m. Kerosene to Tankers (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 0.5$

m. No. 2 F.O. to Tankers (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 2.5$

o. No. 6 F.O. to Tankers (in 10^3 gal/day) = $\dfrac{\qquad\qquad\qquad}{\text{Crude Rate in BPD}} \times 1.5$

PRODUCT LOADING OPERATIONS (Continued)

Defaults (Continued):

II. If method of loading and receiving tank condition are not known, use

   a. Gasoline to Tank Trucks and Cars - EF = 8.0 $lb/10^3$ gal

   b. Jet Naphtha to Tank Trucks and Cars - EF = 2.5 $lb/10^3$ gal

   c. Kerosene to Tank Trucks and Cars - EF = 0.04 $lb/10^3$ gal

   d. No. 2 Fuel Oil to Tank Trucks and Cars - EF = 0.03 $lb/10^3$ gal

   e. No. 6 Fuel Oil to Tank Trucks and Cars - EF = 0.0003 $lb/10^3$ gal

   f. Gasoline to Barges - EF = 4.0 $lb/10^3$ gal

   g. Gasoline to Tankers - EF = 1.4 $lb/10^3$ gal

Example Calculation

FIXED ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

Tank Farm L 7
Diesel Fuel Tank

Breathing Loss

$$LB = (2.21 \times 10^{-4})\ (M)\ \left(\frac{P}{14.7 - P}\right)^{0.68} (D)^{1.73}\ (H)^{0.51}\ (\Delta T)^{0.5}\ (FP)(C)(KC)$$

$$LB = (2.21 \times 10^{-4})\ \underset{130}{(M)}\ \left(\frac{0.02}{14.7 - .02}\right)^{0.68} (120)^{1.73}\ (20)^{0.51}\ (15)^{0.5}\ (1.2)(1)(1)$$

LB = 27.7 lb/day

where: LB = Fixed roof breathing loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 2c.

H = Average vapor space height (ft.), see Default 2d.

ΔT = Average ambient temperature change from day to night (°F), see Default 2e.

FP = Paint Factor (dimensionless), see Default 2f.

C = Small tank adjustment factor (dimensionless), see Default 2g.

KC = Crude oil factor (dimensionless), see Default 2h.

Working Loss

$$LW = (2.4 \times 10^{-2})(M)(P)(KN)(KC)$$

$$LW = (2.4 \times 10^{-2})(130)(.02)(1)(1)$$

LW = 0.0624 $lb/10^3$ gal.

where: LW = Fixed roof working loss (lb/10^3 gal. throughput)
M = see above
P = see above
KN = Turnover factor (dimensionless), see Default 2i.
KC = Crude oil factor (dimensionless), see Default 2j.

Working Loss Per Day

LWPD = (LW)(TP) = $\overset{.0624 \times}{(\ )}\ \overset{124.4}{(\ )}$ = $\underline{\quad 7.8 \quad}$ lb/day

where LWPD = Working loss per day (lb/day)
LW = see above
TP = Average daily throughput (10^3 gal./day), see Default 2k.

Total Emissions Per Tank

TEPT = (LB) + (LWPD) = $\overset{27.7}{(\quad)} + \overset{7.8}{(\quad)}$ = $\underline{\quad 35.5 \quad}$ lb/day

where TEPT = Total emissions per tank (lb/day)

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(N) = $\overset{35.5}{(\quad)}$ (1) = $\underline{\quad 35.5 \quad}$ lb/day

where TEG = Total emissions for a group of identical tanks (lb/day)
TEPT = see above
N = Number of identical tanks in the facility understudy, see Default 1b.

Example Calculation

FLOATING ROOF TANK EMISSION CALCULATION SHEET

(See Default 1)

Tank Farm L 8
Crude Tank

Standing Storage Loss

$$LS = (9.21 \times 10^{-3})(M)\left(\frac{P}{14.7 - P}\right)^{0.7} (D)^{1.5} (VW)^{0.7} (KT)(KS)(KP)(KC)$$

$$LS = (9.21 \times 10^{-3})\overset{50}{(\ )}\left(\frac{3.5}{14.7 - 3.5}\right)^{0.7} \underset{(180)(150)^{.5}}{\cancel{(\ )^{1.5}}} (6)^{0.7} \overset{.045}{(\ )}(1)(1)(.84)$$

LS = 59.7 lb/day

where: LS = Floating roof standing storage loss (lb/day)

M = Molecular weight of the vapor (lb/lb. mole), see Default 2a.

P = True vapor pressure at bulk liquid conditions (psia), see Default 2b.

D = Tank diameter (ft.), see Default 3a.

VW = Average wind velocity (mi/hr), see Default 3b.

KT = Tank type factor (dimensionless), see Default 3c.

KS = Seal factor (dimensionless), see Default 3d.

KP = Paint factor (dimensionless), see Default 3e.

KC = Crude oil factor (dimensionless), see Default 3f.

Withdrawal Loss

$$LWD = \frac{(22.4)(d)(CF)}{(D)} = \frac{(22.4)\overset{7.1}{(\ )}(.02)}{(180)}$$

LWD = 0.0176 lb/10^3 gal. throughput

where: LWD = Floating roof withdrawal loss (lb/10^3 gal throughput)

d = Density of stored liquid at bulk liquid conditions (lb/gal), see Default 3g.

CF = Tank construction factor (dimensionless), see Default 3h.

D = Tank diameter (ft), see Default 1c.

Withdrawal Loss Per Day

LWDPD = (LWD)(TP) = (0.0176)(224.7) = 3.96 lb/day

where: LWDPD = Withdrawal loss per day (lb/day)
TP = Average daily throughput (10^3 gal/day), see Default 2k.

Total Emissions Per Tank

TEPT = (LS) +)LWDPD) = C59.7) + (3.96) = 63.7 lb/day

Total Emissions for a Group of Identical Tanks

TEG = (TEPT)(No. of Tanks) = (1)(63.7) = 63.7 lb/day